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#247 DECEMBER 2025

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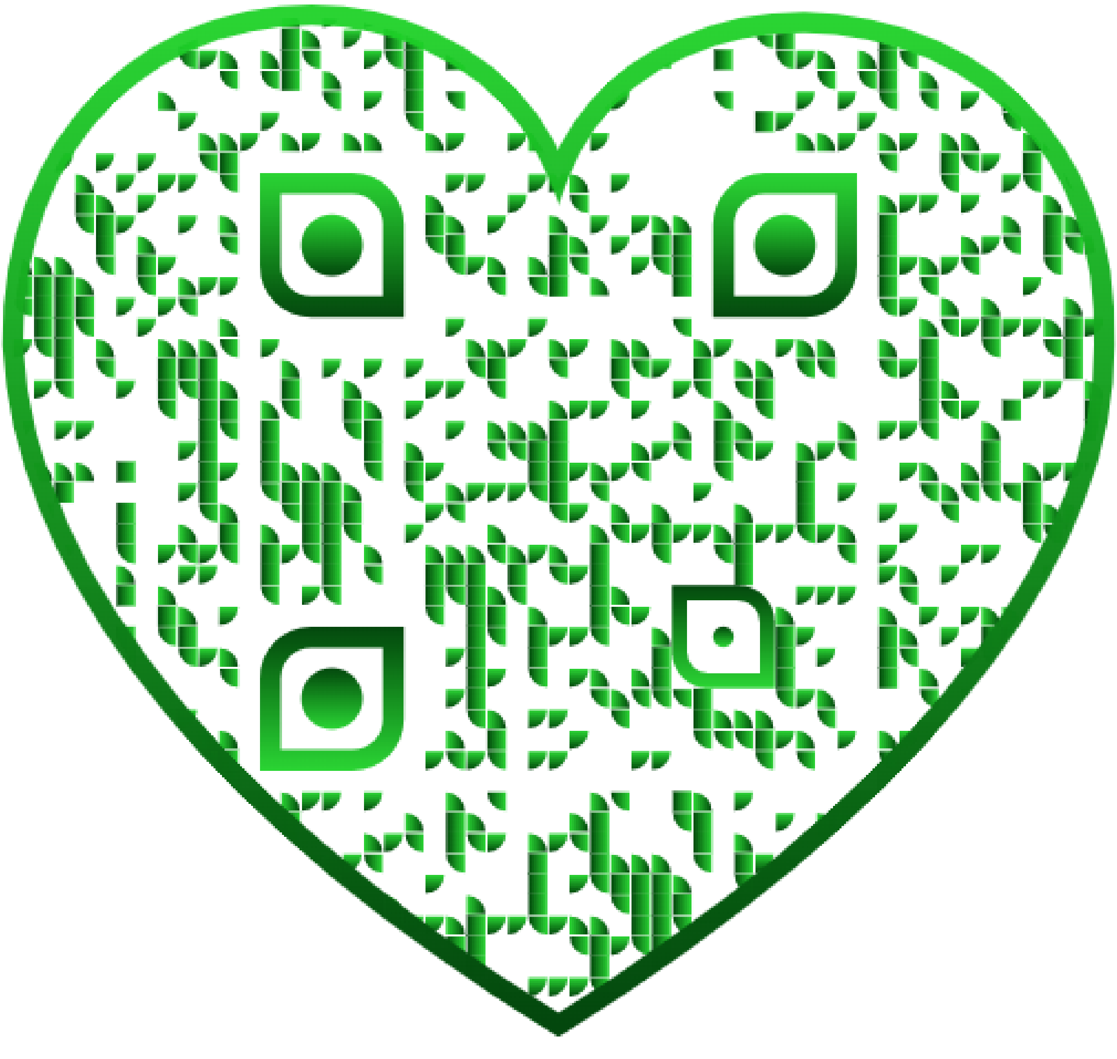

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Welcome

Could *we* be the aliens we're searching for?

How did Earth come to host such an extraordinary abundance of life? It's a question that many branches of science have tried to answer. In astronomy, one theory suggests life didn't begin here at all – it arrived from space, hitching a ride on comets or asteroids. This idea, known as panspermia, isn't new. First put forward in the 19th century, it has gained ground as recent research, including sample-return missions, have brought fresh ways to test it. Join Nick Spall on **page 67** as he explores the evidence.

Back in the late 1800s, we only knew about 500 or so asteroids in the Solar System. Today, that number has soared past 1.4 million! And thanks to smart telescopes, it's now easier than ever for amateur stargazers to get involved in real asteroid science. It's just one of six citizen science programmes that telescope maker Unistellar operates with the SETI Institute. Our reviews editor Charlotte Daniels set up her smart scope and joined the community of home astronomers doing real science from their back gardens. Read all about her experience on **page 28**.

If you're looking for something brighter than an asteroid to observe this December, look no further than **page 60**. Here Stuart Atkinson takes you on a tour of 10 stand-out targets that are easy and rewarding for beginners to find on a first night under the stars. It's the perfect introduction to stargazing if you're unboxing a new telescope this Christmas.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 16 December.

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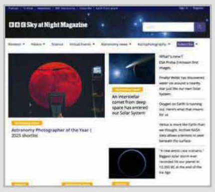
Sky at Night – lots of ways to enjoy the night sky...

The Sky at Night

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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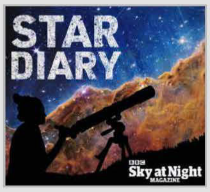

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Ⓒ = on the cover

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From out there to down here: we explore the controversial theory of panspermia

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

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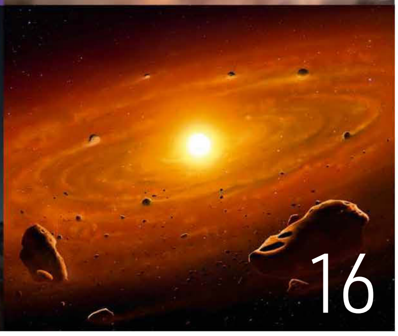
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This month's contributors

Ben Evans

Spaceflight expert

"SpaceX and others now stand on the cusp of a revolution, promising to make access to space cheaper, more routine and more frequent than ever before." **Ben examines the rise and rise of reusable rockets on page 35**

Jane Green

Science journalist

"I really enjoyed revisiting the many reasons that stars twinkle. It's always fun to deconstruct and share why they sparkle as they do." **Jane takes us through the science of scintillation on page 40**

Stuart Atkinson

Seasoned astronomer

"Got a new telescope? The night sky over Christmas will be a great gift for new scope owners." If you're wondering where to point your stargazing present, **Stuart has 10 great suggestions on page 60**

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DECEMBER HIGHLIGHTS

Webb's 'impossible' black holes

Seb Hoenig reveals how studies of the early Universe could show that JWST has got black holes all wrong.

Sky at Night
The Messier catalogue

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Our extended gallery featuring the best astro images sent to us by *BBC Sky at Night Magazine* readers.

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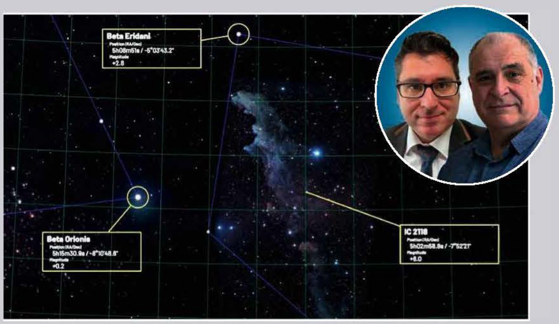


Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

STANDARD CANDLEHOLDER

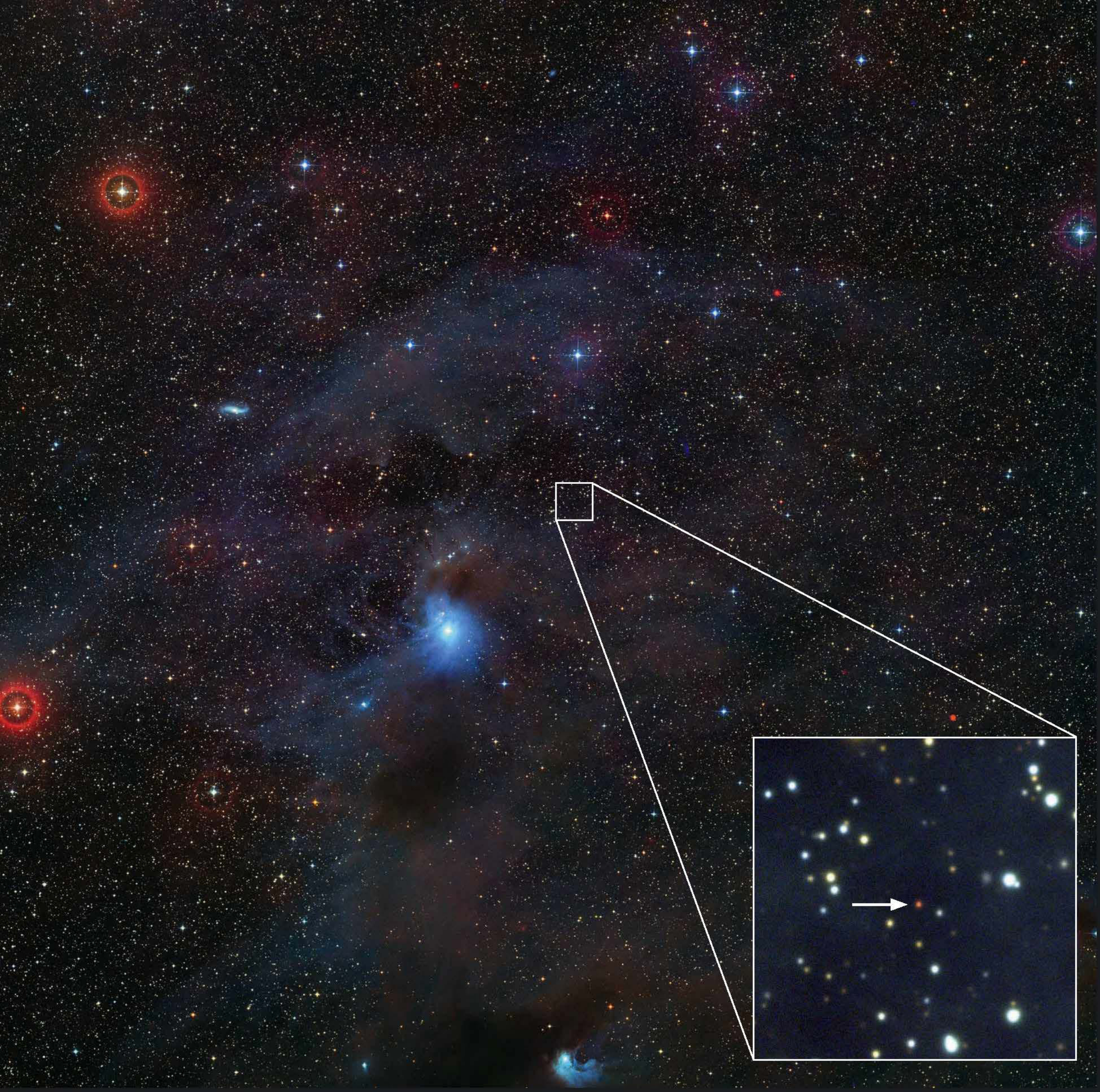
This unassuming galaxy has a few tricks up its spiral arms...

HUBBLE SPACE TELESCOPE, 20 OCTOBER 2025

This swirling beauty is NGC 3370, a spiral galaxy 90 million lightyears from Earth in the constellation of Leo. Hubble has returned to this object time and again because it's home to two phenomena that help unlock the secrets of the cosmos.

The first are Cepheid variables, stars that vary in temperature and brightness at regular intervals, which NGC 3370 has in abundance. The second is a Type Ia supernova, a huge explosion that ended a star's life here in 1994. Both these 'standard candles' help astronomers calculate galactic distances and, from that, how fast the Universe is expanding.

ESA, HUBBLE & NASA, A. RIESS, K. NOLL



◁ Reclusive rogue

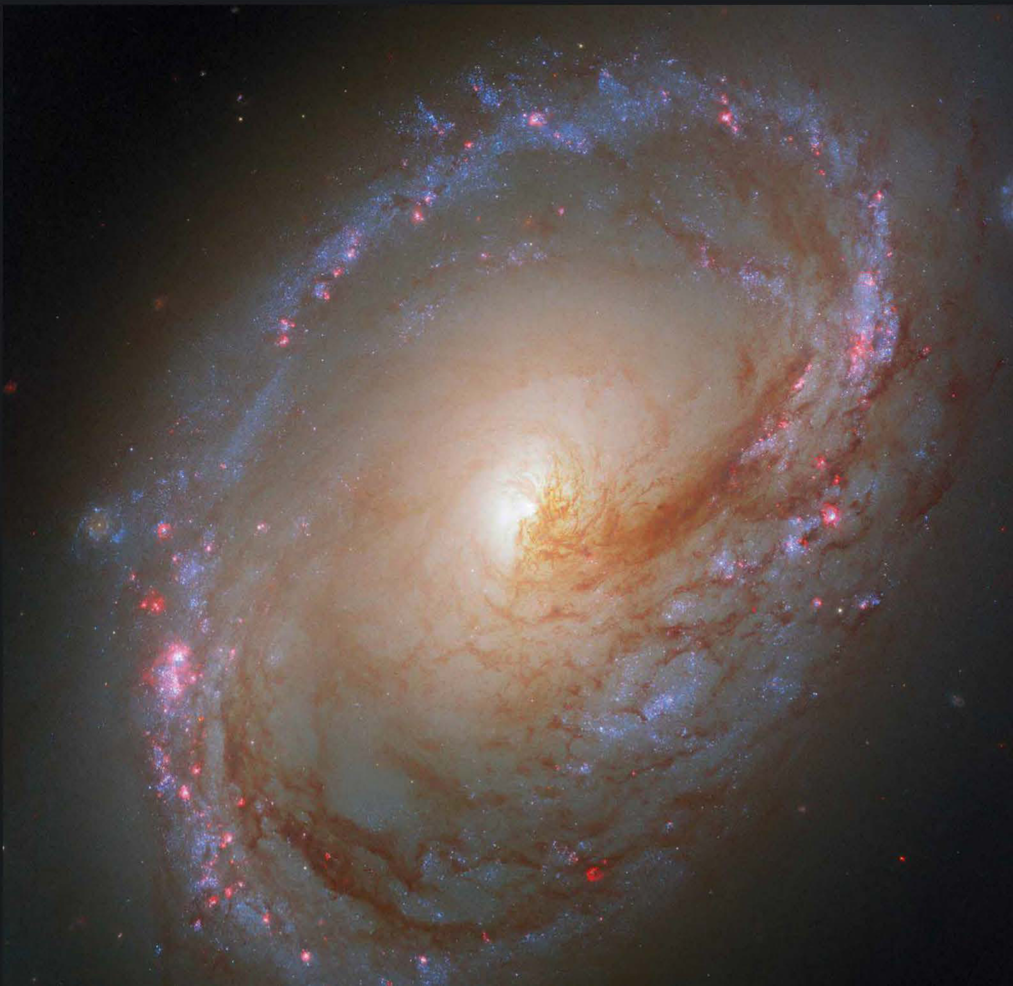
VISTA, 2 OCTOBER 2025

What you can't see in the main image here is rogue planet Cha 1107-7626 – but it is there! This is the Chamaeleon I dark cloud and the mysterious free-floating world lies right in the centre of this image. The planet is seen as an orange-red dot in the inset picture, previously captured by the Victor M Blanco 4-Meter Telescope.

Third time lucky ▷

HUBBLE SPACE TELESCOPE, 25 AUGUST 2025

Spiral galaxy Messier 96 is seen here in its full glory after several portrait sittings with Hubble. The telescope first captured M96 in visible light back in 2015, then added infrared data in 2018. Now ultraviolet joins the mix, revealing regions of star formation (seen in pink) like never before...



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The latest astronomy and space news, written by Jamie Middleton

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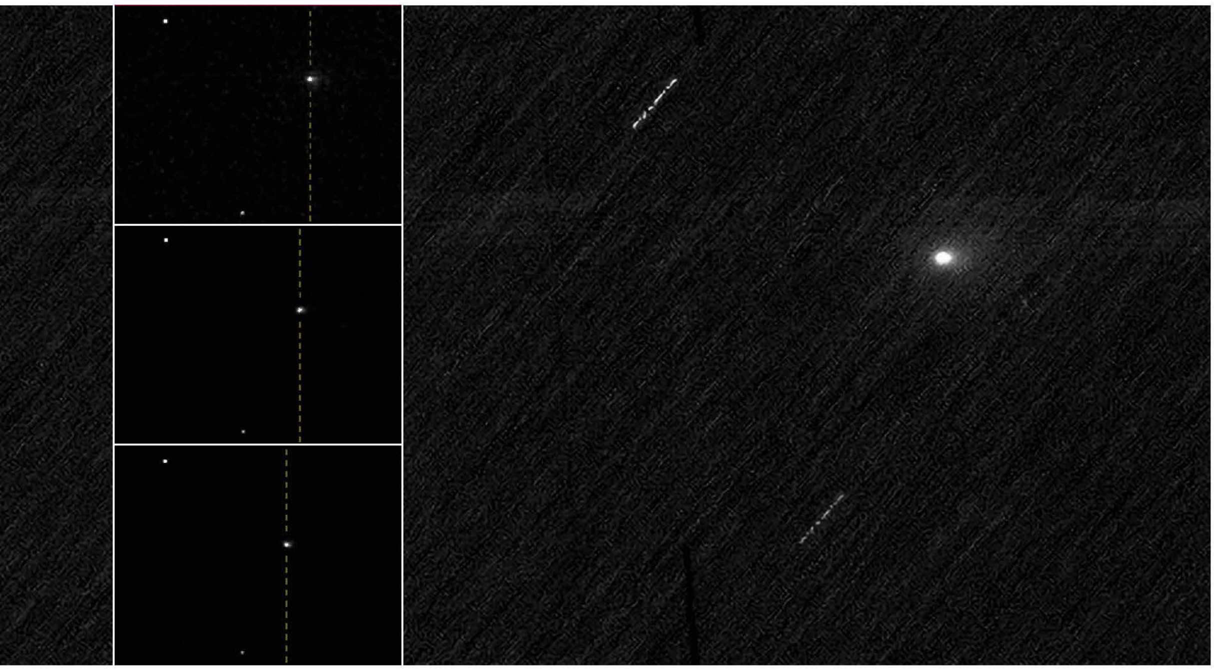


▲ ExoMars Trace Gas Orbiter, orbiting Mars since 2016, used its CaSSIS instrument to image the comet

3I/ATLAS: captured from other worlds

Mars orbiters repurposed to photograph elusive interstellar visitor

When comet 3I/ATLAS skimmed closest to the Sun on 29 October, astronomers had a problem: Earth-based telescopes couldn't see it. So they improvised in order to catch the action, turning Mars orbiters into comet chasers – despite those spacecraft being built for an entirely different job.

ESA's ExoMars Trace Gas Orbiter (TGO) and Mars Express spacecraft both had their missions repurposed in October to capture images of the comet – first spotted in July by NASA's ATLAS survey telescope in Chile – with the best results so far coming from ExoMars's Colour and Stereo Surface Imaging System (CaSSIS).

Although both missions were designed to take close-ups of Mars, astronomers still hope these comet images will provide useful information to help us understand this rare visitor to our Solar System.

As Nick Thomas, principal investigator of CaSSIS, explains: "This was a very challenging observation for the instrument. The comet is around 10,000 to 100,000 times fainter than our usual target."

To be fair to the mission organisers, trying to take a picture of 3I/ATLAS's kilometre-wide nucleus would have been as impossible as seeing a mobile phone on the surface of the Moon from Earth. However, its coma – the fuzzy cloud of gas and dust that surrounds a comet's nucleus – is a few thousand kilometres across and was clearly visible.

Colin Wilson, Mars Express and ExoMars project scientist at ESA, adds: "It's always extra exciting to see our Mars orbiters responding to unexpected situations like this one. I look forward to seeing what the data reveals following further analysis."

These aren't the only missions that could help analyse the comet. ESA's Juice (Jupiter Icy Moons Explorer), currently making its way towards the gas giant, will also turn its cameras towards 3I/ATLAS.

ESA's Hera and NASA's Europa Clipper spacecraft will also pass through the comet's tail at the end of October, and the latter's plasma instrument and magnetometer are exactly what's needed to directly detect ions and changes in the magnetic field in 3I/ATLAS's tail.

But with NASA in shutdown at the time of going to print, the opportunity to be the first spacecraft in the history of humankind to directly analyse an interstellar comet's tail could be missed.

www.esa.int

Comment

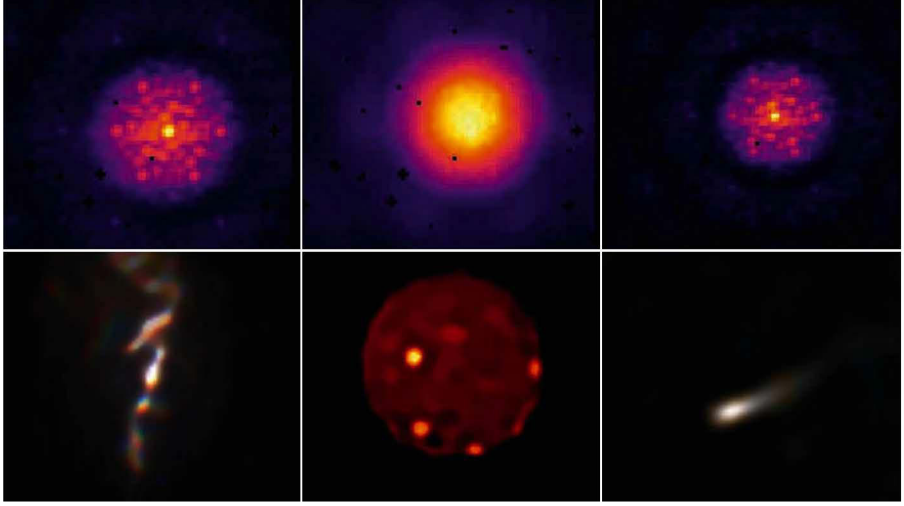
by Chris Lintott

The glimpse of comet 3I/ATLAS in the TGO pictures, released by ESA just a day or so after they were taken, is fabulous. Not because of their quality – though the tiny comet, with clear coma and a hint of a tail has its charms – but because of what it represents.

A spacecraft, flying around Mars could turn and look at a speeding visitor from beyond the outer Solar System. And then it could beam those images back to Earth. That's pretty good science fiction, no? While it's easy to get caught up in wishing our exploration of the Solar System, or the whole Galaxy, could go faster, we humans can already manage some cool things. I'm excited about this one!

Chris Lintott co-presents *The Sky at Night*

ESA, TGO, CASSIS X 4 | MAX CHARLES, UNIVERSITY OF SYDNEY, MAX CHARLES, DR LOUIS DESDOIGTS | STOCKTREK IMAGES, GETTY



▲ Top from left: unprocessed images of NGC 1068, moon Io and star WR 137. Bottom: 'deblurred' images after using algorithms developed by Louis Desdoigts and Max Charles

▲ PhD students Louis (top left) and Max (top right and above) got tattoos of JWST's iconic hexagonal mirror to celebrate

Students fix JWST's blurry vision

PhD researchers restore the telescope's ultra-precise imaging – without a spacewalk

The JWST, the world's most powerful space observatory, is now delivering sharper images than ever, thanks to a software breakthrough by two PhD students from Australia.

After JWST's launch in December 2021, astronomers discovered that its Aperture Masking Interferometer (AMI) – a mode designed for ultra-high-resolution imaging of stars and exoplanets – was underperforming. Subtle electronic distortions in the infrared detector were introducing blur, especially in observations of faint targets.

When the Hubble Space Telescope faced a similar problem, it could only be corrected by a costly Space Shuttle mission and spacewalks, but University of Sydney students Max Charles and Louis Desdoigts found a way to fix JWST's issues from Earth.

"Instead of sending astronauts to bolt on new parts, they managed to fix things with code," explains their tutor Peter Tuthill, who also created the AMI hardware. The solution, called AMIGO (Aperture Masking Interferometry Generative Observations), uses advanced simulations and neural networks to model how JWST's optics and electronics behave in space. The algorithms then 'deblur' the data, restoring the telescope's full potential.

With AMIGO, JWST has achieved its sharpest detections yet of faint objects, including the direct imaging of a dim exoplanet and a nearby brown dwarf.

"It's incredibly rewarding to see a software solution extend the telescope's scientific reach," says Desdoigts. "And to know it was possible without ever leaving the lab." **www.sydney.edu.au**

Clocks on Mars tick faster than on Earth

The discrepancy could cause major problems for future space missions

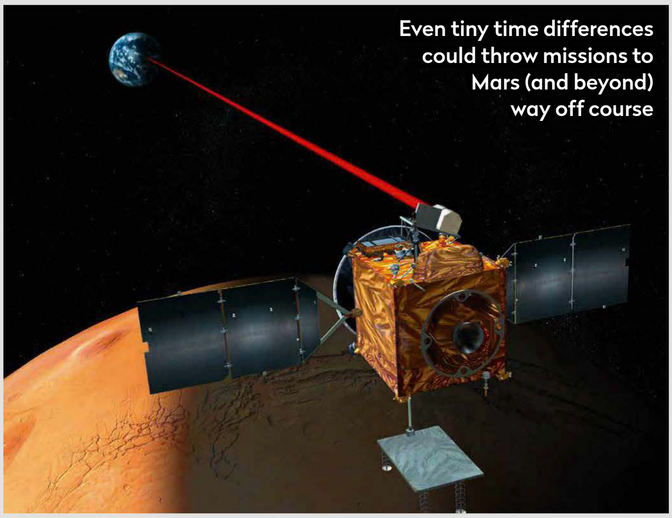
Clocks on Mars tick faster than on Earth by nearly half a millisecond a day, according to new calculations – and the implications for future missions to the Red Planet could be significant.

Neil Ashby and Bijunath Patla at the US National Institute of Standards and Technology calculated that a clock on Mars ticks 477 microseconds faster per day. That rate can also shift by 226 microseconds a day, depending on Mars's distance from the Sun.

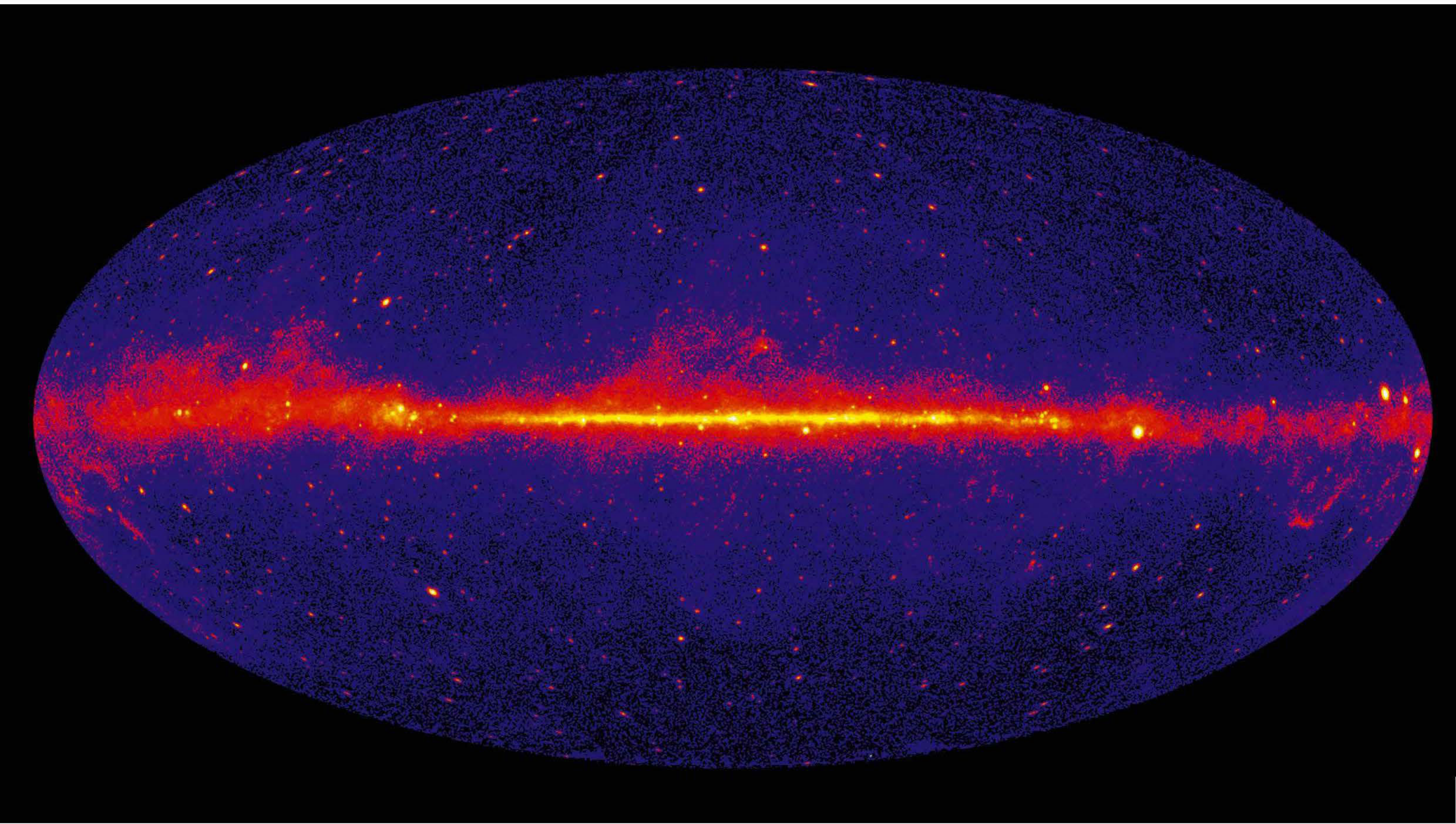
The effect comes from general relativity: weaker gravity and orbital motion alter spacetime, changing how time flows. Surface gravity on Mars is just 38 per cent that of Earth, meaning a second on the Red Planet is slightly shorter than for us on our planet.

Why does it matter? Well, if you're trying to communicate with a rover using radio waves travelling at the speed of light, microseconds count. Even the 56-microsecond delay in radio communications between Earth and the Moon means lunar targets could be missed by the length of about 184 football fields – and Mars is much farther away.

Luckily, we already correct for similar effects in GPS satellites, whose clocks run faster than those on Earth – otherwise your phone's GPS would be misaligned by miles after only a few hours. But it gets a lot more complicated when you are scaling that solution to deal with interplanetary distances, for worlds with different gravities that are moving closer and further from the Sun's gravitational influence.
www.nist.gov



Even tiny time differences could throw missions to Mars (and beyond) way off course



▲ **Fresh models have strengthened the case for dark matter being behind the Milky Way's gamma-ray excess**

Mysterious glow could be dark matter

New map suggests elusive substance lies at the heart of our Galaxy

The centre of our Galaxy is a mysterious place. For decades, astronomers have puzzled over the strange glow emanating from the Milky Way's core. Made up of gamma rays, its origins remain uncertain. The two prevailing theories are that the source of the rays is either dying stars called millisecond pulsars (rapidly rotating neutron stars) or, more excitingly, colliding dark matter particles.

Now, new research suggests that the chances of it being dark matter are higher than previously thought, although it still puts the chances of either theory being correct at 50/50.

If confirmed, this would be the first concrete evidence that this elusive substance exists.

"Dark matter dominates the Universe and holds galaxies together. It's extremely consequential and we're desperately thinking all the time of ideas as to how we could detect it," says study co-author Joseph Silk, a professor of physics and astronomy at Johns Hopkins University. "Gamma rays, and specifically the excess light we're observing at the centre of our Galaxy, could be our first clue."

To test the idea, the researchers fed data on the Milky Way's formation into a supercomputer. This then calculated a map of where dark matter is likely to have ended up as our Galaxy formed.

Their simulated maps closely matched actual gamma-ray observations by the Fermi Gamma-ray Space Telescope. Although this isn't definitive proof, the similarities certainty add weight to the dark matter theory. Add to this the fact that there haven't been enough millisecond pulsars observed to explain the mysterious glow and the amount of gamma rays detected, and you can see why researchers are excited.

The argument could be settled with the construction of a huge new gamma-ray telescope called the Cherenkov Telescope Array. Planned for 2030, this will allow the energies of the gamma rays to be measured. If they are high-energy rays, then that would point to pulsars; if they are low-energy rays, that would indicate dark matter collisions.

"A clean signal would be a smoking gun, in my opinion," says Silk. "It's possible we will see the new data and confirm one theory over the other. Or maybe we'll find nothing, in which case it'll be an even greater mystery to resolve."

www.jhu.edu

NASA, DOE, FERMI LAT COLLABORATION | NASA, ESA. ACKNOWLEDGEMENT: JOSH LAKE | MARK GARLICK, SCIENCE PHOTO LIBRARY, GETTY

The star – almost pure hydrogen and helium – came from the halo of the Large Magellanic Cloud

Scientists find the purest object in the Universe

Most pristine star ever discovered is a rare survivor of the Big Bang era

Astronomers have discovered a primeval star that is the most pristine ever found. Thought to be a relic from the Universe's earliest days, it has far fewer heavier elements like carbon, oxygen and iron than stars seen today.

Named SDSS J0715-7334, the star is mostly composed of hydrogen and helium, closely resembling the first-ever stars (population III stars) that formed after the Big Bang. These were thought to have been massive, hot and short-lived, and responsible for forging heavier elements through nuclear fusion.

As the research team, led by Alexander Ji from the University of Chicago, state in the new study: "This star has the most pristine composition of any object known in the Universe. SDSS J0715-7334 is over 10 times more metal-poor than the most metal-poor high-redshift galaxies found by the James Webb Space Telescope."

Their analysis shows that the star contains just 0.8 parts per million of heavy elements, which makes it around 20,000 times purer than the Sun.

This also makes it a candidate for one of the earliest stars ever found and calls into question assumptions that these kind of stars had long since exploded. "The first stars formed out of pristine gas, causing them to be so massive that none are expected to have survived until today," the authors explain.

Previous theories suggested that any surviving pristine stars would contain a comparatively high level of carbon, enough to cool the stars and allow them to burn for longer. However, this star has little carbon, making it an even more intriguing find.

physicalsciences.uchicago.edu

Did the Moon's birth give Earth its water?

A colossal planetary smash-up may have delivered the essentials for life

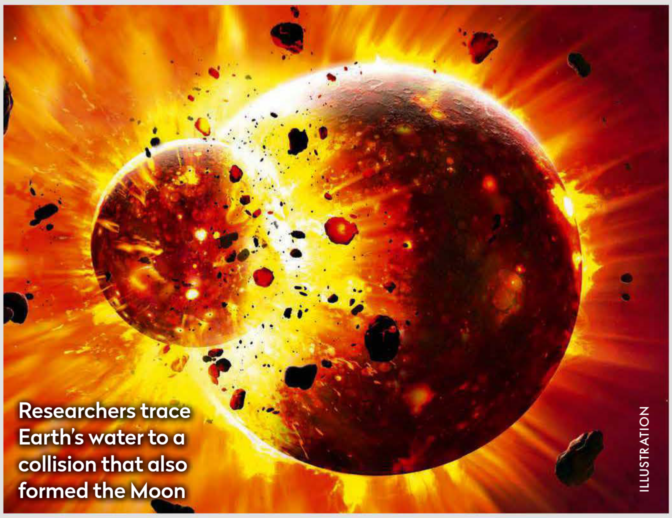
Our blue-green planet didn't used to be so blue. And without the blue, there would be no green either. But how Earth acquired and retained the water that allows life to exist has long been debated.

As with the other inner planets of the Solar System, the forming Earth is thought to have been stripped of volatile elements like hydrogen, helium and water by the Sun's heat. So how did we get them?

While the prevailing theory is that they arrived via meteorite bombardment, a new study from the University of Bern in Switzerland suggests Earth's water came from a collision between the proto-Earth and another planet. This planet, called Theia, smashed deep into the early Earth, delivering water and also ejecting a huge chunk that became the Moon. This could also help explain why life is so rare in our Solar System – the young Earth was the only planet to get hit.

The team used isotope and element data from meteorites and rocks, and the decay of manganese-53, to model when Earth's chemistry changed.

"Thanks to our results, we know that the proto-Earth was initially a dry rocky planet," explains lead author Pascal Kruttasch. "It can therefore be assumed that it was only the collision with Theia that brought volatile elements to Earth and ultimately made life possible there."



Researchers trace Earth's water to a collision that also formed the Moon

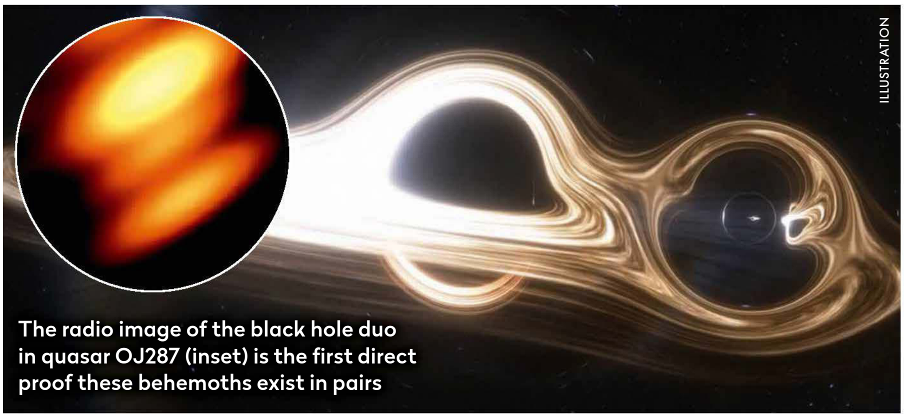
ILLUSTRATION

Co-author Klaus Mezger adds: "Earth does not owe its current life-friendliness to a continuous development, but probably to a chance event – the late impact of a foreign, water-rich body."

www.unibe.ch

First-ever photo of black holes orbiting each other

The image shows a duo locked in a death spiral, confirming a 40-year-old theory



The radio image of the black hole duo in quasar OJ287 (inset) is the first direct proof these behemoths exist in pairs

Scientists have captured the first-ever visual proof of two supermassive black holes locked in a death spiral. It has long been suspected that black holes can come in pairs, but this is the first time the phenomenon has been imaged.

The international team behind the capture used data from the now-defunct RadioAstron radio satellite. The two singularities, located 4–5 billion lightyears away from Earth, were given away by the powerful streams of plasma and energy ejected from their poles. The capture is an impressive feat – the equivalent of photographing a coin on the surface of the Moon.

"For the first time, we managed to get an image of two black holes circling each other," explains lead researcher Mauri Valtonen. "In the image, the black holes are identified by the intense particle jets they emit. The black holes themselves are perfectly black, but they can be detected by these jets or by the glowing gas surrounding the hole."

The pair were found in the centre of a quasar called OJ287, which has long been thought to harbour a black hole pair, due to its light output fluctuating on a 12-year cycle. The idea that this dimming and brightening was a sign of a binary black hole system dates back to the 1980s, but this new radio image is the first-ever confirmation of the theory.

The smaller black hole's jet may be a previously unseen type of particle stream. It appears to be twisting around like a spinning garden hose as it rotates around its larger counterpart – although this is yet to be verified.

"The RadioAstron satellite was in operation a decade ago, when OJ287 was imaged," says Valtonen. "Its radio antenna went half-way to the Moon, which greatly improved the resolution of the image."

www.utu.fi

Earth-based telescopes could rival those in space

New algorithm strips away atmospheric interference to bring stars into greater focus

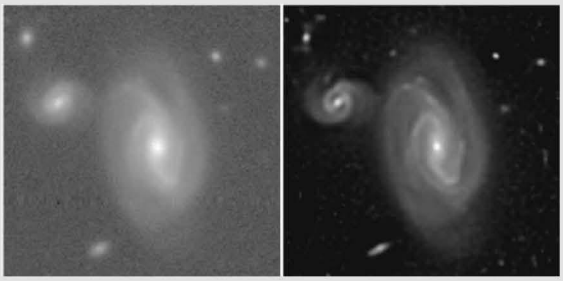
Observatories based on Earth have a constant problem: our atmosphere distorts starlight as it makes its way to the ground. That's why we put telescopes in space to avoid the interference. Now, researchers at Johns Hopkins University have come up with a mathematical solution that could give ground-based telescopes near space-quality vision.

Called ImageMM, the algorithm models how light travels from the stars and how it's influenced by our atmosphere. "Think of the atmosphere as a restless sheer curtain, constantly shifting and shimmering, so the scene behind it always looks blurred," says Yashil Sukurdeep, who helped develop the algorithm. "Our algorithms learn to see past that curtain, reconstructing the still, sharp image hidden behind it."

"By sharpening our view of the sky, we can see farther, fainter targets and push the threshold of what's detectable," adds Tamás Budavári, who led the research. "That will open new opportunities to improve cosmology research and revolutionise how we process astronomical observations."

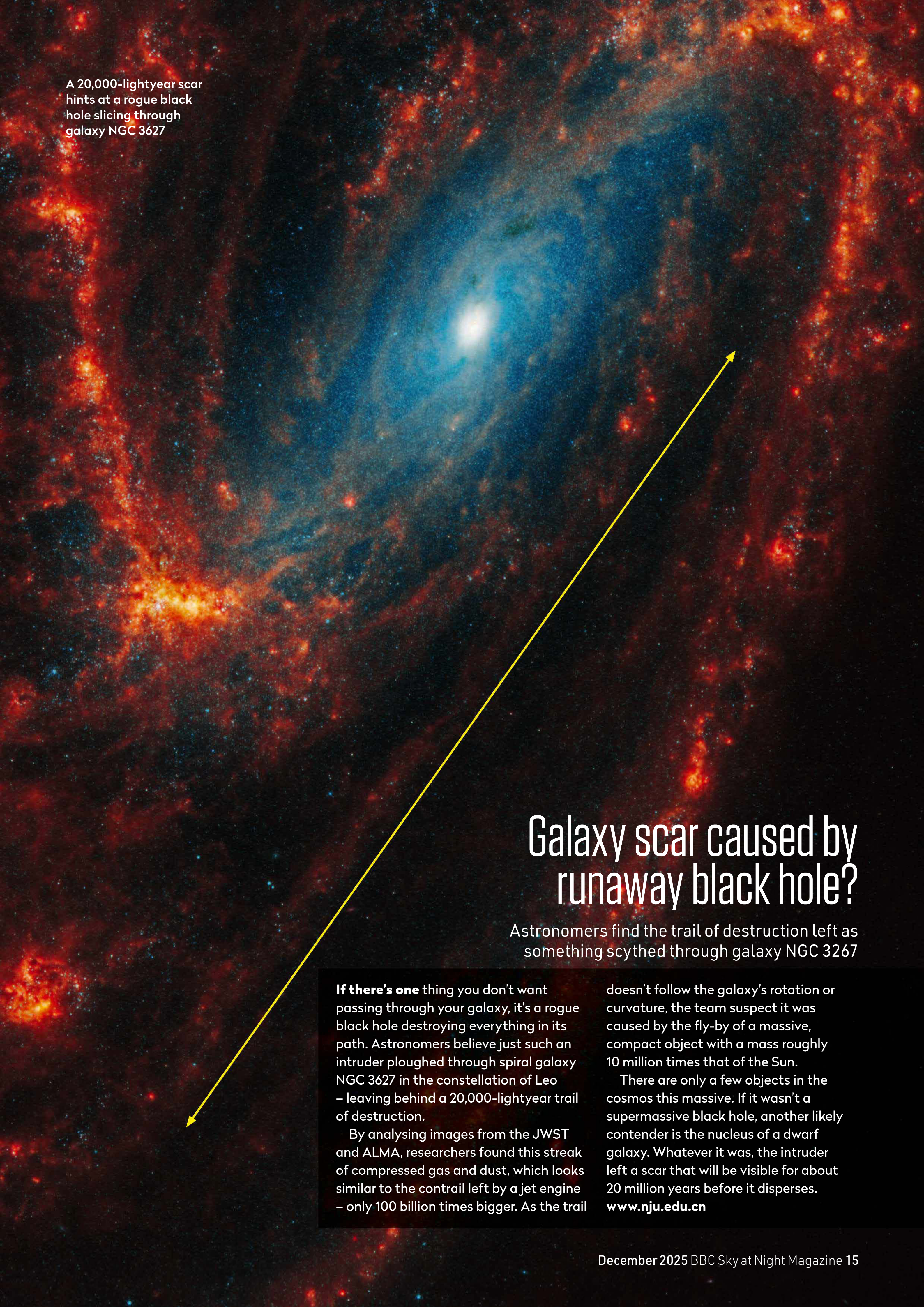
This will push the boundaries of what is observable from Earth, and the new algorithm is already being tailored for the Rubin Observatory's upcoming sky survey. "Our framework can recover a near-perfect image from a series of imperfect observations," says Sukurdeep. "We'll never have ground truth, but we think this is as close as it currently gets to perfect."

hub.jhu.edu



▲ **An image from the Subaru Telescope in Hawaii, before and after the new algorithm**

AIVREASASTII | J.L. GOMEZ AND ET AL, 2022 | JOHNS HOPKINS UNIVERSITY X 2 |
NASA, ESA, CSA, STSCI, J. LEE (STSCI), T. WILLIAMS (OXFORD), PHANGS TEAM



A 20,000-lightyear scar hints at a rogue black hole slicing through galaxy NGC 3627

Galaxy scar caused by runaway black hole?

Astronomers find the trail of destruction left as something scythed through galaxy NGC 3267

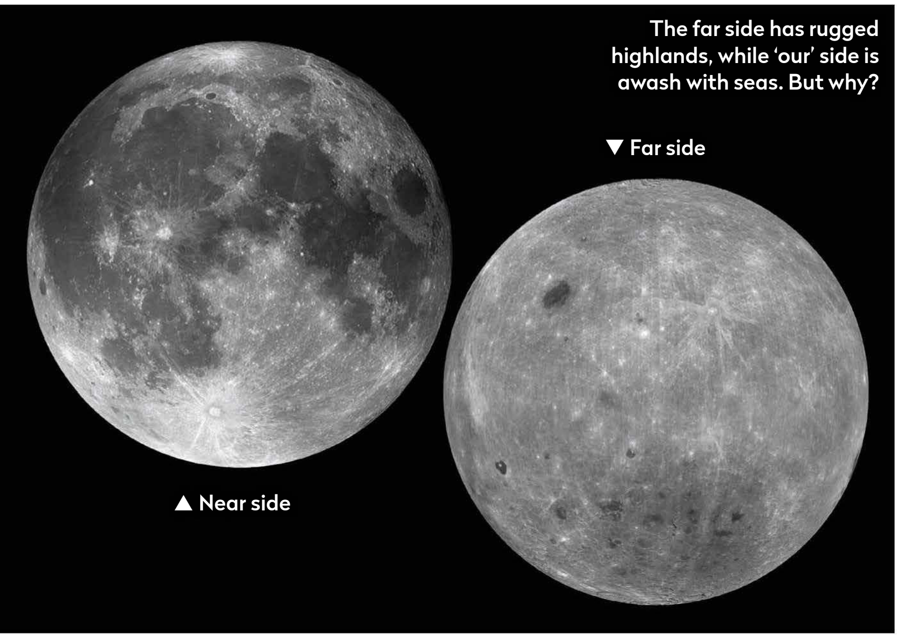
If there's one thing you don't want passing through your galaxy, it's a rogue black hole destroying everything in its path. Astronomers believe just such an intruder ploughed through spiral galaxy NGC 3627 in the constellation of Leo – leaving behind a 20,000-lightyear trail of destruction.

By analysing images from the JWST and ALMA, researchers found this streak of compressed gas and dust, which looks similar to the contrail left by a jet engine – only 100 billion times bigger. As the trail doesn't follow the galaxy's rotation or curvature, the team suspect it was caused by the fly-by of a massive, compact object with a mass roughly 10 million times that of the Sun.

There are only a few objects in the cosmos this massive. If it wasn't a supermassive black hole, another likely contender is the nucleus of a dwarf galaxy. Whatever it was, the intruder left a scar that will be visible for about 20 million years before it disperses. **www.nju.edu.cn**

Our experts examine the hottest new research

CUTTING EDGE


The far side has rugged highlands, while 'our' side is awash with seas. But why?

NEAR SIDE: PETE LAWRENCE, FAR SIDE: NASA, JPL, USGS | MARK GARLICK, ALAMY

Moon's split personality solved

Ancient heat imbalance may explain our Moon's two-faced appearance

Contrary to what Pink Floyd say, there is no dark side of the Moon. The Moon rotates on its axis once every orbit around Earth, and so, like us, experiences day and night periods (albeit very protracted). But this tidal locking does mean that one side of the Moon always faces our planet – and there's a curious difference between the lunar near and far sides.

The near side is dominated by vast, dark plains of solidified lava – the maria or 'seas' – whereas the far side is more heavily cratered, with mountainous highlands. In fact, the almost complete lack of dark maria means the far side is actually brighter than the side facing us. The Moon has a fundamental asymmetry in its surface structure: the crust is much thicker on the far side than on the near side.

Scientists think they've got a pretty good handle on how the Moon formed. Very early in the Solar System's history, a Mars-sized object slammed into the proto-Earth. The massive amounts of material thrown into orbit coalesced into the Moon, with both planet and its new satellite remaining molten for a significant period afterwards. Minerals crystallised as the Moon's global magma ocean cooled, with the lightest of these, such as plagioclase, floating to the top to form the grey-coloured crust. But it's still something of a mystery as to why the Moon formed with such a stark contrast between the far-side and near-side crust, a conundrum that's known as the 'lunar far-side highlands problem'.

One hot, one cold

Various theories have been proposed over the decades to explain this difference between the Moon's two sides. Perhaps there was a difference in the number of impacts striking the near side and far side? Or maybe more minerals condensed on the far side from a searing, rocky atmosphere?

But many of these competing explanations fail to account for all the observed features of the Moon. For example, in 2011, Martin Jutzi and Erik Asphaug argued that maybe a second, smaller satellite also formed after the giant impact, and later splatted itself across one side of the Moon. However, this doesn't fit with the smooth variation in elemental abundances around the lunar surface.

Now, Wenshuai Liu in Henan Normal University's school of physics, China, has come up with a new hypothesis. He argues that after the Moon became tidally locked, the two sides experienced different levels of heating. The far side, warmed only by sunlight would have cooled to a temperature of around –20°C. But the near side would have been kept at nearly 1,000°C by the heat radiating from the still-molten surface of Earth. Liu compares the situation to lava exoplanets orbiting so close to their host star that the near side is hot enough to melt rock.

> ***"The far side would have cooled to around –20°C, but the near side would have been kept at 1,000°C by heat from the still-molten Earth"***

This lunar temperature gradient set up a global circulation in the magma (like water convecting in a saucepan), with cooler, denser material downwelling on the far side and a surface current flowing from near to far. Floating plagioclase crystals were transported to pile up into a much thicker crust on the far side; as the far side was cooler, crystallisation here would also be more efficient.

It's a neat explanation for the lunar far-side highlands problem. But at the moment, Liu's hypothesis is just that – a supposition, one that he plans to test very soon with simulations of the proposed process.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Origin of the Lunar Farside Highlands from Earthshine-induced Global Circulation in Lunar Magma Ocean* by Wenshuai Liu **Read it online at: arxiv.org/abs/2509.11199**

Can life's ingredients survive planet birth?

Lab models pinpoint survival zones inside young planetary systems

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

When the OSIRIS-REx spacecraft returned its sample of asteroid Bennu to Earth, scientists around the world scrambled to get their hands on its precious cargo. The early results justify their excitement: Bennu, which is believed to be largely unaltered since the early days of the Solar System, has surprisingly complex chemistry. Even molecules as complex as amino acids appear to be liberally sprinkled throughout.

Results like these have intensified interest in the chemistry that takes place in protoplanetary discs, where objects like Bennu – and Earth – form. If complex molecules form naturally in such conditions, then it's possible that the ingredients for life could be delivered to newly formed and forming planets.

To understand the soup of chemicals we now expect in protoplanetary discs, we rely on a plucky band of laboratory chemists doing experiments here on Earth that replicate what's happening up in space. While they can't reproduce the passage of millions of years, they can investigate particular processes – and that's what Harvard astrochemistry experts have done in this month's paper.

Aromatics under fire

Their target is a class of organic molecules known as aromatics, which have structures that involve a ring of carbon atoms. Aromatics like benzene are believed to be the building blocks from which more complex organic chemicals – like those amino acids on Bennu – can be built. Understanding when and where they should be found, and where they might react to form other compounds, is therefore a big source of debate in astrochemical circles.

We do see these molecules in comets (in addition to asteroids like Bennu), but it's not clear if that's because they've been available for reactions from the beginning, or if they've reformed later on. What we need to know is if such molecules can survive in the harsh conditions in a warming protoplanetary disc, or if the star's radiation easily destroys them.

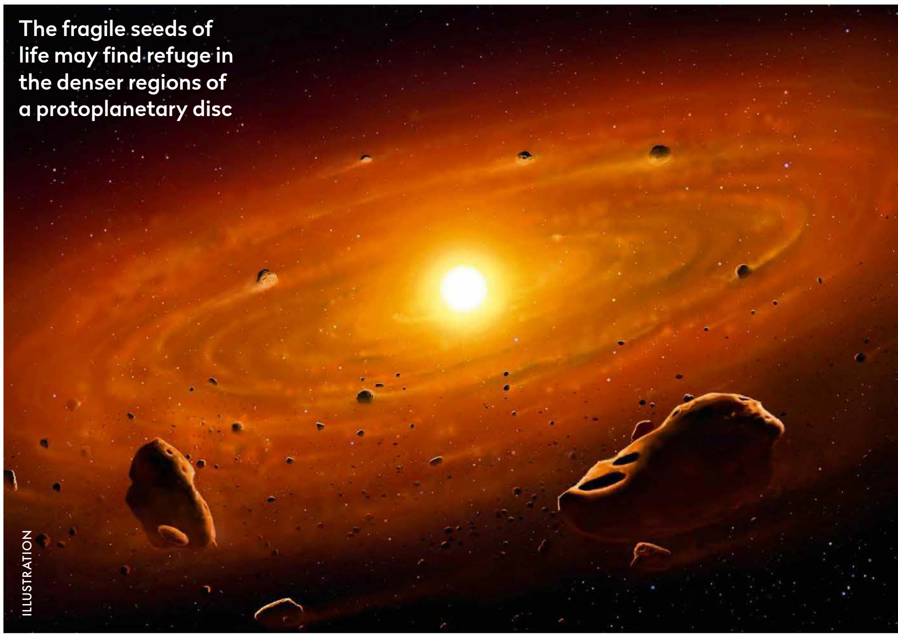
> ***"On the surface of the protoplanetary disc, where there's no hiding from the star's light, aromatic compounds will be quickly destroyed"***

In the initial stages of planet formation, aromatic compounds will exist as ice, most likely mixed with simpler molecules like water and carbon monoxide. The Harvard team created such ice within a cooled vacuum chamber, which they then irradiated with ultraviolet light. The results show that, as ever with complex chemistry, the devil is in the details.

Whether the aromatic compounds survived their harsh treatment seemed to depend partly on how they were mixed in with the other compounds; they were more likely to survive in pure ice. What was clear, though, was that when exposed to the kind of UV typical of a young star, aromatics rarely survived long.

On the surface of the protoplanetary disc, where there's no hiding from the star's light, such molecules will therefore be quickly destroyed. In the heart of the disc, the sheer density of material will shield ice from the harsh light of the star. And in between, there will be a region where molecules can survive, but where there is enough UV to induce chemical reactions that might be needed to process the aromatics and form more complex organics.

These relatively simple lab experiments may be pointing us to a part of the disc where all sorts of things can form and later be incorporated into newly forming planets.



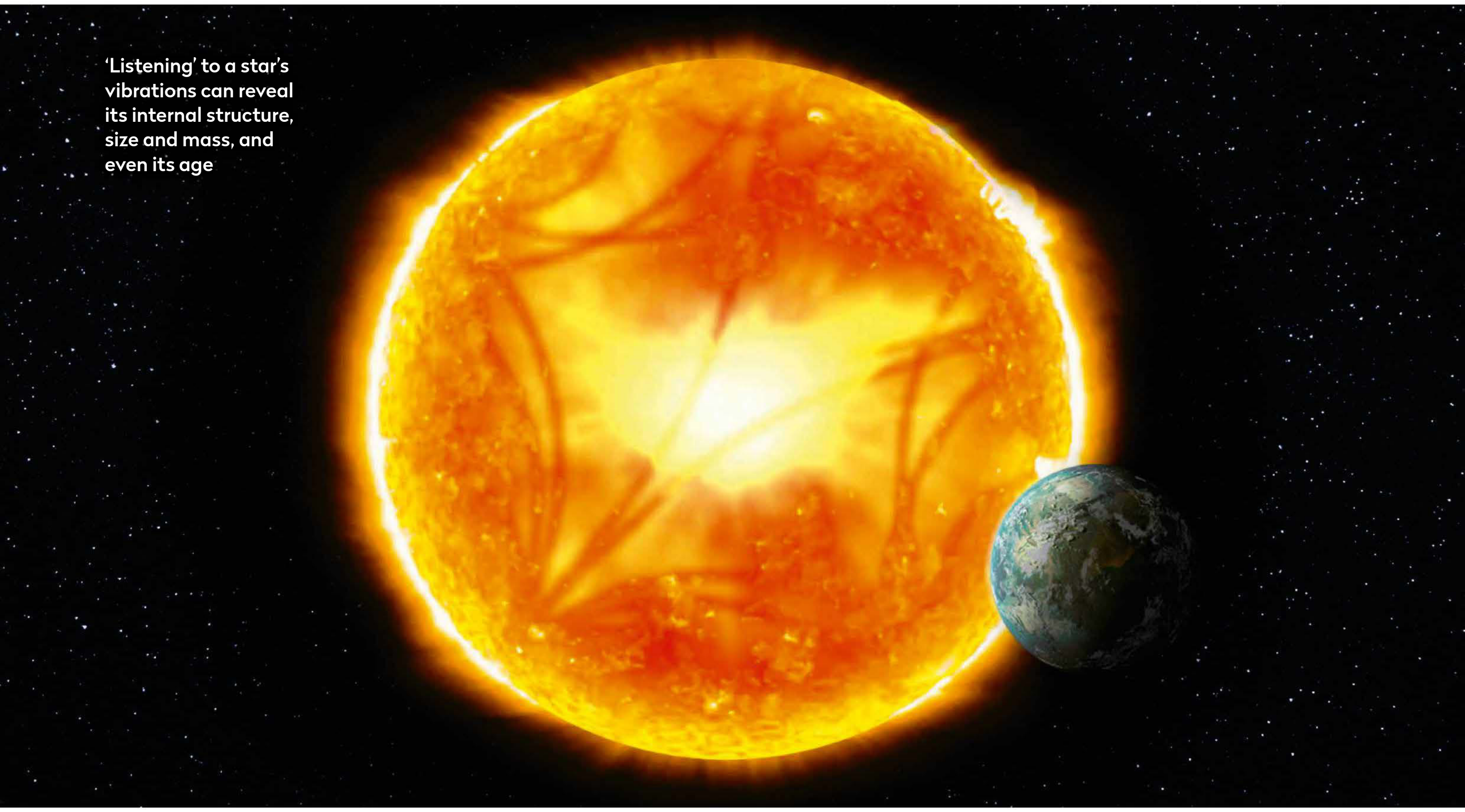
The fragile seeds of life may find refuge in the denser regions of a protoplanetary disc

ILLUSTRATION

Chris Lintott was reading… *The Survival of Aromatic Molecules in Protoplanetary Disks* by Elettra L Piacentino, Aurelia Balkanski et al. **Read it online at: arxiv.org/abs/2510.09797**

Behind the scenes of *The Sky at Night* TV show

INSIDE THE SKY AT NIGHT


'Listening' to a star's vibrations can reveal its internal structure, size and mass, and even its age

When *The Sky at Night* joined *Curious Cases* for a special episode, **George Dransfield** was there to answer your burning questions. Here she dives deeper into her favourite

A lot has happened since I last wrote this column a month ago. Taylor Swift released new music, I submitted observing proposals for both JWST (two hours before the deadline) and the VLT (seven minutes before the deadline), and I had a chat in Spanish with Dara Ó Briain. At least one of those events has the potential to shape the direction of my research in 2026.

Why was I in Dara's vicinity? It's because for the final *Sky at Night* episode of the year we did a crossover with *Curious Cases*, the awesome science podcast he co-hosts with Hannah Fry. Filming took place 48 hours before the JWST deadline, so it's honestly some sort of miracle I got that in with two full hours to spare. I wasn't filming before the VLT deadline though, so no excuses there!

There's a lot that's brilliant about this special episode of the show, but I'll boil it down to my top two. First, I finally got to talk about asteroseismology, the study of stellar oscillations, the periodic vibrations of stars. For years, I shared an office with the asteroseismologists at the University of Birmingham, and there was always a friendly rivalry between the 'wobbly star people' (them) and the 'slimy rock people' (us exoplanet folk).

Despite the joking around, I find it disgustingly cool that we can figure out so much about stars just from making funky graphs of their wobbles. So when a viewer sent in a question for our *Curious Cases* crossover episode on the subject of stars making sounds, I didn't just jump, I *leapt* at the chance to link this to asteroseismology. To do the

George Dransfield is an exoplanet huntress at the University of Oxford and a presenter on *The Sky at Night*

> *"We can figure out so much about stars just from making funky graphs of their wobbles"*

ESA | DR MARTIN NIELSEN | NASA

topic justice, I reached out to my friend and board-gaming buddy, Dr Martin Nielsen (who is only a tiny bit taller than me – see photo below) for his best wobbly star facts. I hit the main points, but his best analogy evaporated from my brain on the day (possibly fried with JWST stress).

So here it is now: Martin described it as similar to repeatedly flicking a water-filled balloon; the particular way it wobbles will be related to both the size of the balloon and the density of the contents. This is the principle on which asteroseismology – or starquakes, if you like etymology – is based. That's because the waves travelling through stars are sound waves and – just like with musical instruments – the size and material impacts the sound wave produced.

Dating wobbly stars

What's less intuitive is that we can also estimate a star's age this way, because the speed of sound inside the star depends on how matter is distributed inside it. This changes throughout a star's lifetime, as it works its way through all its available nuclear fuel. Stars are powered by fusing hydrogen into helium; the helium is heavier, so it sinks into the core and makes it denser, which dramatically changes the speed of sound. Isn't that wild? We (well, Martin) can infer how old a star is from little wobbles on its surface. And if you think these wobbles need to be fast to be detectable from (literally) trillions of miles away, think again. They move at approximately walking speed. It's enough to give you chills.

My second favourite thing about this episode is that people get to enjoy it in two formats. It'll be on TV as a *Sky at Night* episode, but it'll also be a *Curious Cases* episode on BBC Radio 4 (or as a podcast on BBC Sounds)!

Speaking of podcasts: Chris Lintott from *The Sky at Night* and I have decided to start one! We'll cover astro news, what we've been up to (last-minute telescope proposals?) and take one deep dive into something nerdy. Our first episode should be out in the next few weeks, when we are finally clear of proposal season for the year!

To the folks who miss their *Sky at Night* fix when the show is off air: this is for you. To everyone else: this is also for you. But mostly, I think it's for us – because what could be more fun than getting together with a friend to talk about space?

How to watch

Catch the show on the

BBC iPLAYER

George alongside asteroseismologist (wobbly star expert) Dr Martin Nielsen

The Sky at Night

Relive the triumphs and tragedies of the Space Shuttle programme

13 Minutes Presents: The Space Shuttle

BBC SOUNDS

The Sky at Night is taking a break for the rest 2025 and will return in 2026. In the meantime, there's plenty more astronomy and space content on the BBC's on-demand services. In the latest series of the *13 Minutes* podcast, Maggie Aderin-Pocock explores the history of NASA's Space Shuttle. Relive the days of this iconic piece of space history, from its design and launch to its final mission. The 10-part series is available on BBC Sounds at **www.bbc.co.uk/sounds**

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MESSAGE OF THE MONTH

When life gives you Lemmon...

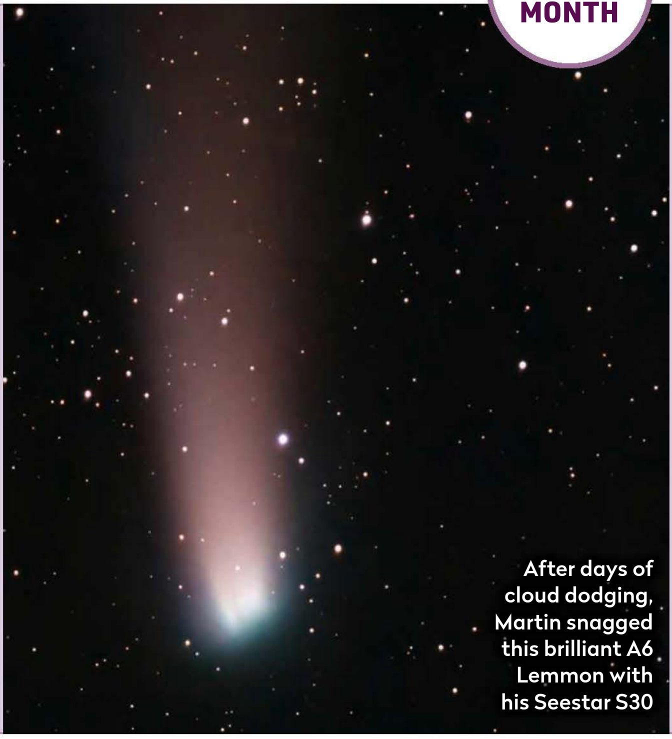
I've just read Stuart Atkinson's account of his trials and tribulations whilst trying to capture comet A6 Lemmon (www.skyatnightmagazine.com). I was smiling as I read, because it almost exactly matched my own frustrations.

I have been waiting for the comet to brighten enough to image with my Seestar S30 smart scope, and have twice in the last week got excited by clear, blue, daytime skies, only to have my hopes dashed by evening clouds rolling in off the Atlantic.

I had all but given up until today. While not cloudless, at least the clouds were separate and fast-moving. I managed to gather nearly 30 minutes of data from our Bortle 2 sky and only had to discard a handful of subs due to passing satellites. All the best and clear skies to you.

Martin Goodey, Isles of Scilly, UK

A fantastic image, Martin. Well done for persevering; your efforts have certainly paid off! – ***Ed.***



After days of cloud dodging, Martin snagged this brilliant A6 Lemmon with his Seestar S30

David was another reader ready to pounce as soon as the clouds cleared

Lucky break

On 20 October, once I'd located it with binoculars, comet Lemmon was easily visible with the naked eye from east Norfolk. This picture was captured on the first clear morning for over a week!

David Bryant, Norfolk, UK

Lost in translation

Your piece in Bulletin (October issue) on Betelgeuse's companion mentions that the star's name is derived from Arabic, meaning 'the hand of al-Jawza'. 'Bet', pronounced 'beit', is the Arabic word for 'house'. Should the researchers reconsider the name given to the star's companion?

Thomas Jones, via email

There's some interesting history here, Thomas. The original Arabic name for the star is Yad al-Jawza, which does mean 'hand of al-Jawza'. However, when this was translated into medieval Latin, the 'Y' was misread as a 'B', since the difference between the two letters in Arabic script is a single dot. This error has persisted ever since. – ***Ed.***

Instagram

hikes_with_louise
• 20 October

I've been chasing the aurora for a fair few years now, and the excitement and anticipation is still as exciting as it ever was. Mother Nature at its best.

@bbcskyatnightmag

Skylab next?

Having just read the review of Andy Saunders' book *Gemini and Mercury Remastered* (October issue), I was wondering if there are any plans to do similar with Skylab? I've had a long interest in space and had a VHS cassette of one of the Skylab flights, the quality of ▶

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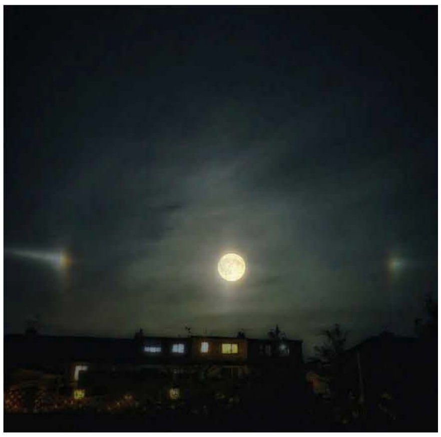
▶ which was poor. I'd love to see more of the work that was done on Skylab in high definition.
Mike Alcock, via email

Hello halo

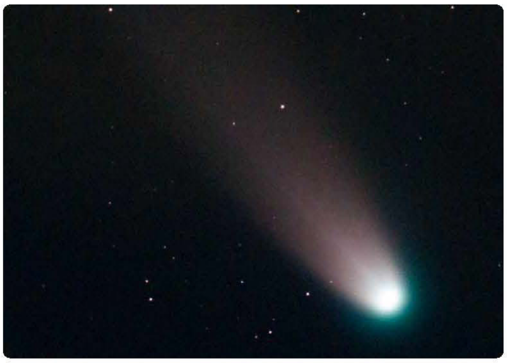
I thought I'd send this picture (right), as it captures something I've never seen before in such dramatic style. I went out to capture the Harvest Moon on 6 October, when I was amazed to see this atmospheric display. Moondogs like I've never seen before – wow! This was captured on my Pixel 9 mobile phone and edited with Snapseed.
Anton Matthews, Bristol, UK



▲ Moondogs unleashed! Anton's halo, snapped during October's Harvest Moon

Tweet

Steven Lomas
@StevenLomas10
• 21 October
I got up at 3.30 this morning and headed out to the coast with my new telescope to photograph comet Lemmon C/2025 A6 on its closest approach to the Earth today. It won't return for 1,350 years. #cometlemmon @skyatnightmag



CORRECTION

In 'The hunt for alien tech' (November issue), the technosignatures expert we cited was Jason Wight, not Jason Wright as originally published.

SOCIETY IN FOCUS

Founded in 1903, **Manchester Astronomical Society** is one of the UK's oldest. It began life in 1892 as the North West branch of the British Astronomical Association, before members broke away to form MAS at the Godlee Observatory. The society flourished under early presidents such as Rev Thomas H Core and Father Aloysius Cortie, hosting lectures by such luminaries as Sir Arthur Eddington and Sir Bernard Lovell. We've been nurturing amateur and professional astronomers ever since.

In 2023, the historic Godlee Observatory closed for redevelopment, prompting a move to the Blackett Lecture Theatre at the University of Manchester. Our observatory's future may be uncertain, but we remain committed to fostering astronomical curiosity and education from our temporary home, with continued outreach and guest speakers as we enter our 123rd year.

▲ Tom Vassos's talk to MAS members on 'humanity's star-studded origins'

Recent highlights include a lecture by Dr Mark Clampin, NASA's astrophysics division director, on the James Webb Space Telescope. We have a full calendar of events in 2026, including monthly lectures from October to March, observing sessions and public talks geared towards beginners and seasoned stargazers. Prospective members are welcome to attend meetings as guests before joining.
Sonia Turkington, vice president
▶ **www.manastro.org**

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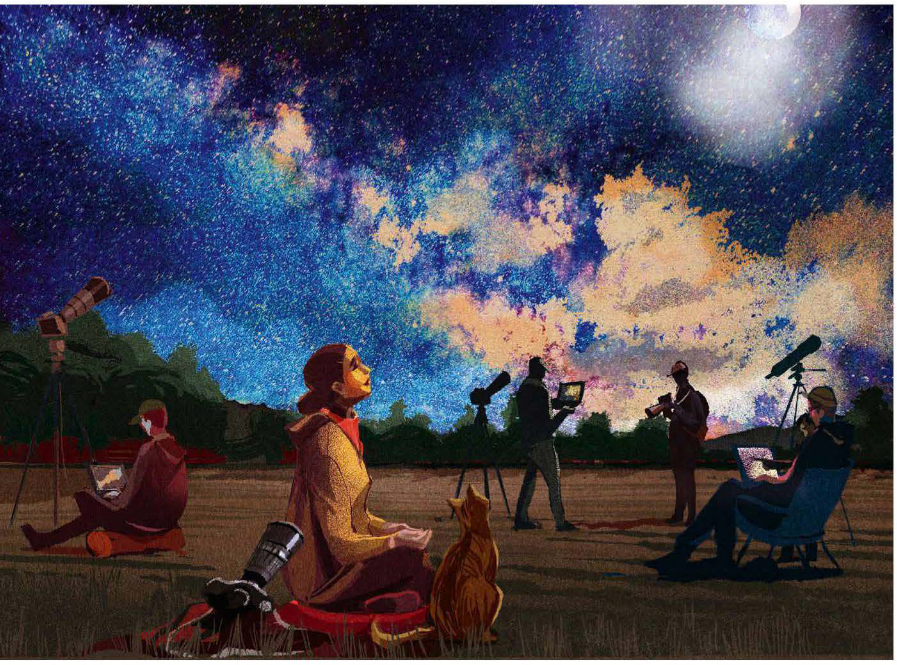
FIELD OF VIEW

Forget Instagram – embrace the moment

When did stargazing become just a photo op? Ditch the filters and the checklists, says **Mark Westmoquette**. The night sky is best experienced, not posted



Author of *The Mindful Universe*, astronomer and mindfulness teacher **Mark Westmoquette** lives with his young family in London and can be reached at www.markwestmoquette.co.uk

It's easy to forget that the power of the stars to evoke awe and connection lies in our willingness to experience their beauty directly, in the moment. When we get caught up in trying to capture that experience or get distracted by analytical thoughts, the magic disappears. At best, our experience loses colour. At worst, we get lost in a disconnected world, like James Joyce's Mr Duffy, who "lived a short distance from his body".

Nowadays, so many of us fail to appreciate how important it is for our mental health not to get stuck in a disembodied "pics or it didn't happen" mentality – the modern notion that unless an experience is recorded and posted online, it didn't really happen. For example, I recently spoke to a renowned astrophotographer about what it is to stargaze mindfully. When I asked how she'd feel about being under the stars and simply looking, without taking her camera, she gasped. She felt sure she wouldn't cope with not having a way to record the experience!

Last year, I was the astronomer on board a cruise to see the Northern Lights. When the announcement came that the aurora had been spotted, the whole ship rushed to the top deck. I was taken aback to find that most people were watching the spectacle only on their phone screens. Another group had their heads down, frantically fiddling with their camera settings. And as quickly as they'd rushed out, photos now taken, they rushed back into the warm. Northern Lights? Tick!

This kind of behaviour is driven in large part by social media and the desire to gain the approval of others through how many likes we get. But it also reflects how disconnected we've become from nature, both in the day and the night. We get lost in ideas, thoughts and worries about our experience and miss the reality of the here and now.

I've seen, and heard from, many amateur astronomers who spend all night looking at their screens, tweaking knobs and checking cables and batteries, forgetting to look up at what's above their heads. I was once like this too. I've written before about my time as a professional astronomer, working at a telescope on Mauna Kea, Hawaii. Back then, I was so caught up in the data and the science that I didn't look at the night sky once with my own eyes.

Part of what makes any moment so wonderful is its full-bodied, multi-dimensional, unInstagrammable and, of course, ephemeral nature. An idea or photograph captures only a fragment of that.

Stargazing in a mindful way means stepping out of the world of ideas and into the world of experience and being. It means putting aside the wish to capture the experience and instead immersing yourself in it directly. It means appreciating the fleeting, ungraspable nature of experience – and indeed, allowing that to infuse the moment with even more beauty.

So, what would you say to going out under the stars without your camera (or binoculars or telescope), and wholeheartedly plunging into the experience of that moment? Don't let yourself get swept away by thoughts about it. The next clear night, simply look, listen and feel.

ALEX GREEN, FOLIO

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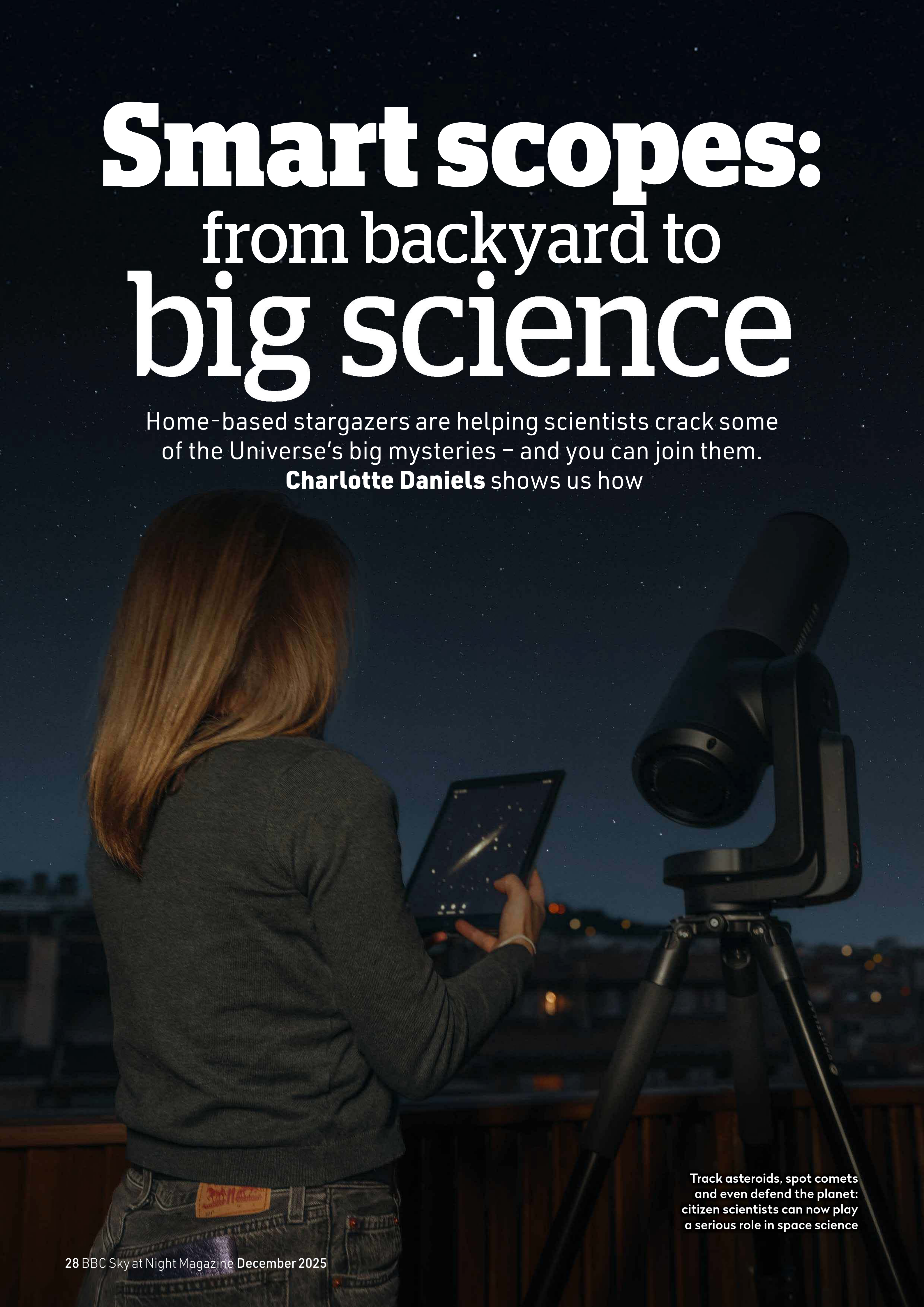
News

Smart scopes: from backyard to big science

Home-based stargazers are helping scientists crack some of the Universe's big mysteries – and you can join them. **Charlotte Daniels** shows us how



Track asteroids, spot comets and even defend the planet: citizen scientists can now play a serious role in space science

The rise of smart telescopes has opened up astrophotography to a whole new audience, providing an accessible and rewarding route into what can seem like a complex hobby. But these high-tech telescopes are doing something else too: they're getting ordinary citizens involved with helping astronomy professionals to study the cosmos.

In 2020, the SETI Institute joined forces with telescope maker Unistellar to develop the Unistellar Network, a community of over 25,000 Unistellar users worldwide who, across several astronomical programmes, share observations from their smart telescopes with scientists.

Almost six years on, citizen scientists in the Unistellar Network have made significant contributions that have been recognised in research papers. In 2022, 34 citizen scientists captured data to determine the rotation period of near-Earth asteroid 7335 during a close approach, while others helped observe NASA's attempt to deflect an asteroid, the DART mission. They also observed interstellar comet 3I/ATLAS almost immediately after its detection in July 2025, and asteroid 2025 RL2 was captured as it passed only half a lunar distance away in September 2025, despite being just 17–37 metres (55–121ft) wide.

At the heart of the network is the Unistellar smartphone app and the Slack messaging platform, where lead astronomers for each programme moderate a designated channel and bring trends to the attention of users. Here, processed observation data is uploaded in the form of videos and reports, and important upcoming missions are highlighted.

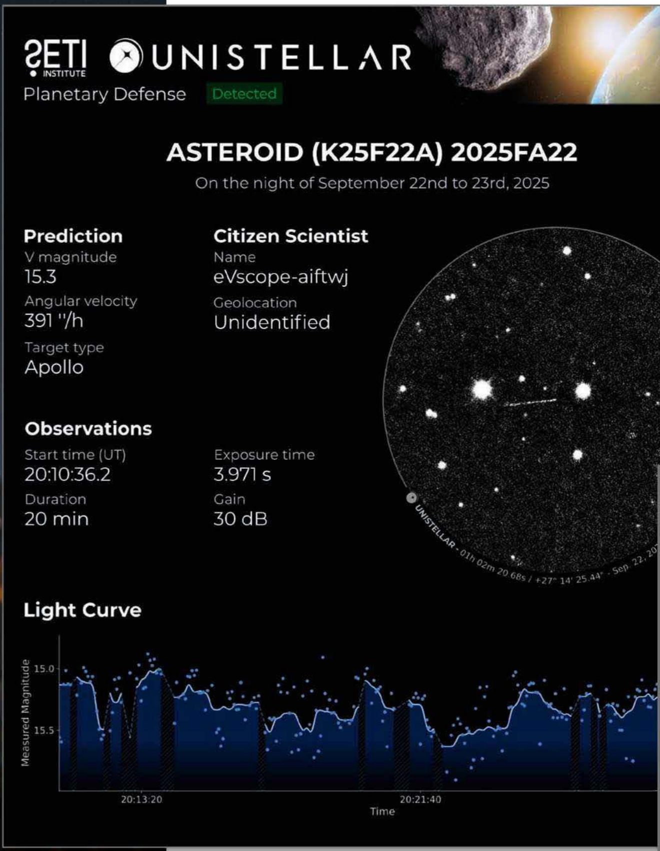
So how does it all work, and how can you take part? Join us as we explore the network, with our Unistellar Odyssey Pro smart telescope at the ready, and discover how you can turn your stargazing into scientific discovery.

Defend the planet

First up on our tour is Planetary Defense, Unistellar's programme to observe asteroids, potentially hazardous objects (PHOs) and other near-Earth objects (NEOs), with a view to helping scientists understand these space rocks' trajectories and detect potential changes.

The 'Missions' page already featured several candidates for us to observe, curated by SETI Institute scientists, including 2025 FA22, a 130–290-metre-diameter (426–951ft) asteroid that came within 2.2 lunar distances of Earth on 17 September 2025. Its peak magnitude of ~13 made this a candidate for the Odyssey Pro's 85mm aperture, and while poor weather meant we couldn't observe the close approach, we captured this object soon after! ▶

UNISTELLAR | ALL SCREENSHOTS: CHARLIE DANIELS



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Planetary Defense Detected

ASTEROID (K25F22A) 2025FA22

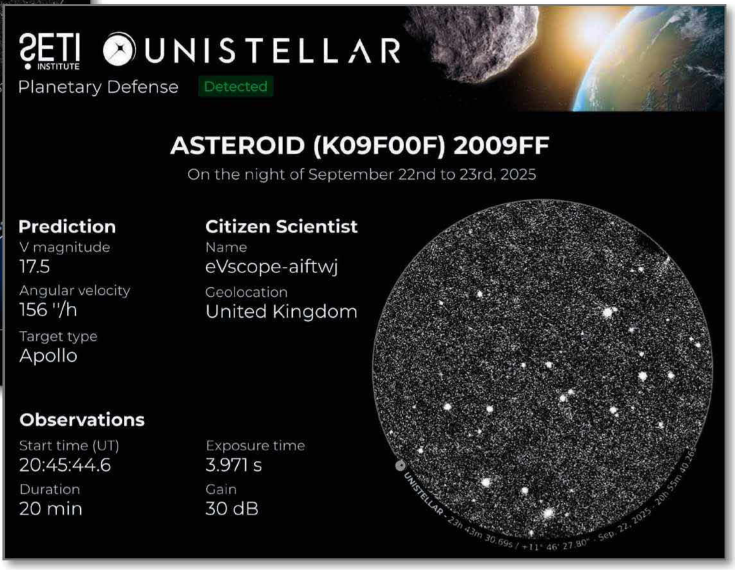
On the night of September 22nd to 23rd, 2025

Prediction
V magnitude
15.3
Angular velocity
391 ''/h
Target type
Apollo

Citizen Scientist
Name
eVscope-aiftwj
Geolocation
Unidentified

Observations
Start time (UT)
20:10:36.2
Duration
20 min
Exposure time
3.971 s
Gain
30 dB

Light Curve



SETI INSTITUTE UNISTELLAR

Planetary Defense Detected

ASTEROID (K09F00F) 2009FF

On the night of September 22nd to 23rd, 2025

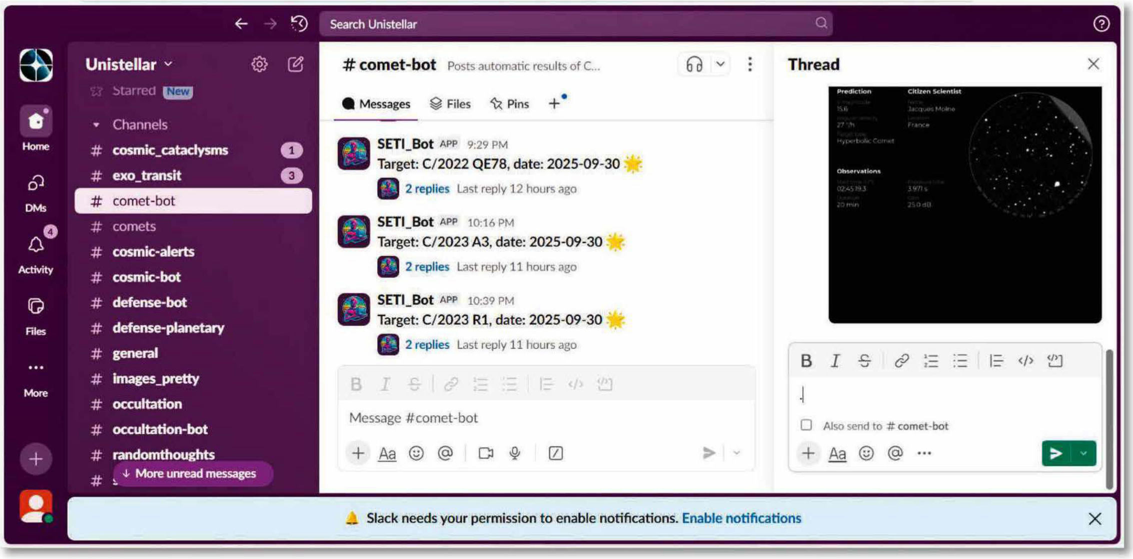
Prediction
V magnitude
17.5
Angular velocity
156 ''/h
Target type
Apollo

Citizen Scientist
Name
eVscope-aiftwj
Geolocation
United Kingdom

Observations
Start time (UT)
20:45:44.6
Duration
20 min
Exposure time
3.971 s
Gain
30 dB

UNISTELLAR - 23h 43m 30.69s / +11° 46' 27.80" - Sep. 22, 2025 - 20h 55m 40.26s

▲▶ Join the search for hazardous objects such as asteroid 2025FA22, which briefly topped ESA's Risk List for impact with Earth, and 2009FF, which recently came closer to us than it has for 150 years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Target: C/2022 QE78, date: 2025-09-30
2 replies Last reply 12 hours ago

SETI_Bot APP 10:16 PM
Target: C/2023 A3, date: 2025-09-30
2 replies Last reply 11 hours ago

SETI_Bot APP 10:39 PM
Target: C/2023 R1, date: 2025-09-30
2 replies Last reply 11 hours ago

Slack needs your permission to enable notifications. Enable notifications

◀ **The network uses Slack to keep in touch with members, share data and videos, and flag up promising targets**

▶ As asteroids are moving objects, you need to create something called an 'ephemeris file' – a table of predicted positions – to find them. Heading to the 'Ephemeris' page from the Unistellar app allowed us to use our smartphone's GPS to enter our location and, after inserting a date and time for observation, a JPL ephemeris was created with a deep link that let us insert it straight into the app.

The optimum capture settings were also automatically updated in the app, including gain and exposure time, meaning that we simply had to hit 'record' to start observing. After filling in an observation report to confirm the time, we received our processed data a couple of days later.

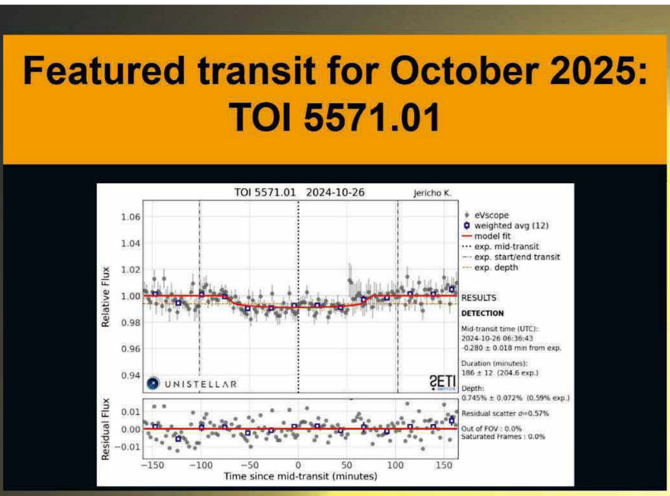
Find a new planet

Next up is the programme to find exoplanets, planets that orbit stars outside our Solar System. Smart scope users can help detect them by observing their transits – the moments when a planet passes in front of its parent star. These transits are revealed in light curves: as the planet blocks out some of the star's light, it causes the light curve to dip. Observing these dips is one way of confirming exoplanets, and citizen science data helps scientists to determine the exoplanet's size and orbit.

We joined the hunt from the 'Find Your Event' page at www.science.unistellar.com, where we highlighted 'Exoplanet Transits' and typed in our location. This revealed a list of exoplanet transits that were visible from our back garden over a clear evening. Clicking a candidate took us to a map that confirmed whether we could observe all or part of a transit. The Slack channel also had lots of information on particular objects of interest, with scientists encouraging as many users as possible to observe these.

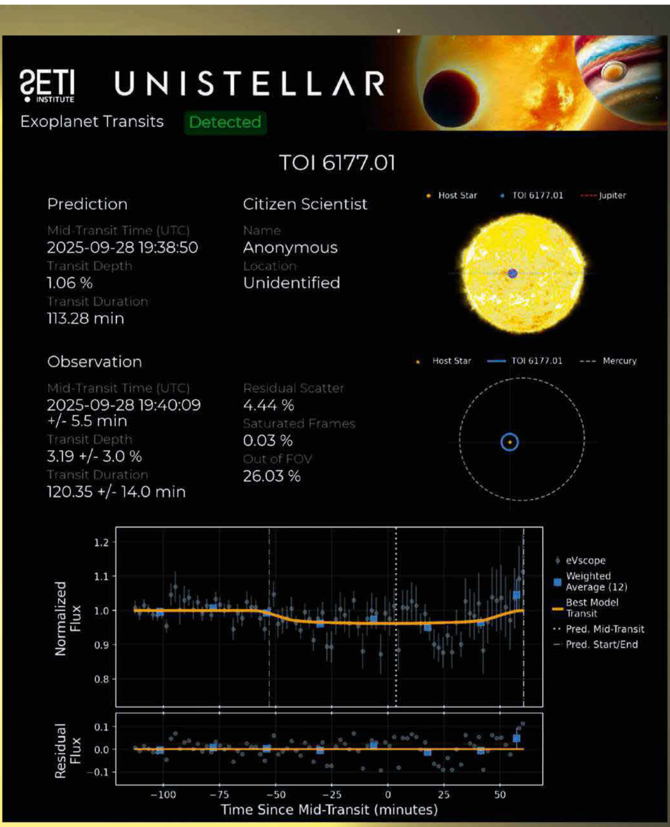
▼ **Left: light curve for TOI 5571.01 – volunteers are helping to confirm whether it really is a planet**

Right: our observation of a Neptune-like planet passing in front of its star


Featured transit for October 2025:
TOI 5571.01

TOI 5571.01 2024-10-26 Jericho K.

RESULTS
DETECTION
Mid-transit time (UTC):
2024-10-26 06:36:43
-0.280 ± 0.018 min from exp.
Duration (minutes):
186 ± 12 (204.6 exp.)
Depth:
0.745% ± 0.072% (0.59% exp.)
Residual scatter σ=0.57%
Out of FOV : 0.0%
Saturated Frames : 0.0%


SETI INSTITUTE UNISTELLAR
Exoplanet Transits Detected

TOI 6177.01

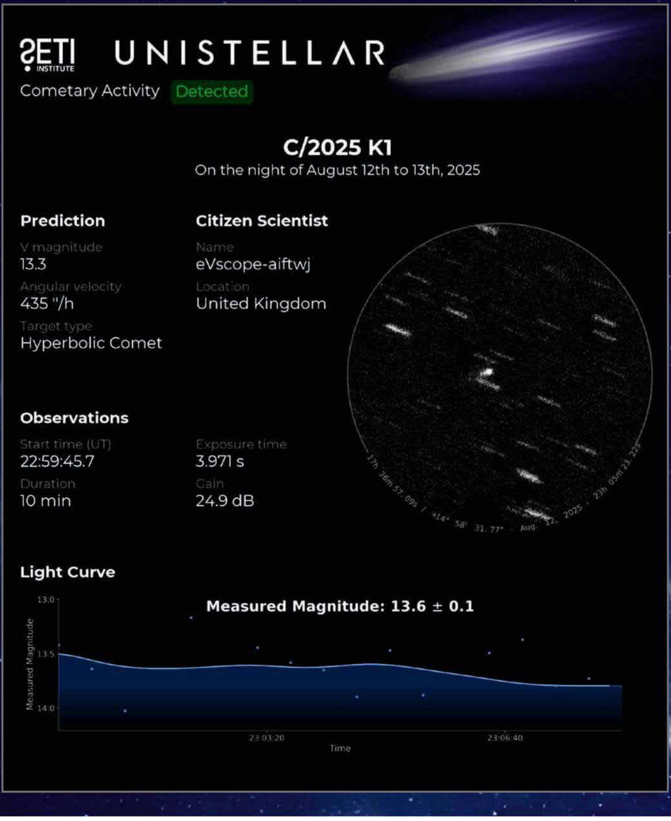
Prediction
Mid-Transit Time (UTC)
2025-09-28 19:38:50
Transit Depth
1.06 %
Transit Duration
113.28 min

Citizen Scientist
Name
Anonymous
Location
Unidentified

Observation
Mid-Transit Time (UTC)
2025-09-28 19:40:09
+/- 5.5 min
Transit Depth
3.19 +/- 3.0 %
Transit Duration
120.35 +/- 14.0 min

Residual Scatter
4.44 %
Saturated Frames
0.03 %
Out of FOV
26.03 %
Host Star
TOI 6177.01
Jupiter
Host Star
TOI 6177.01
Mercury
Normalized Flux
1.2
1.1
1.0
0.9
0.8
Residual Flux
0.1
0.0
−0.1
−100
−75
−50
−25
0
25
50
Time Since Mid-Transit (minutes)
eVscope
Weighted Average (12)
Best Model Transit
Pred. Mid-Transit
Pred. Start/End

ILLUSTRATION



SETI INSTITUTE UNISTELLAR

Cometary Activity Detected

C/2025 K1

On the night of August 12th to 13th, 2025

Prediction

V magnitude
13.3

Angular velocity
435 "/h

Target type
Hyperbolic Comet

Citizen Scientist

Name
eVscope-aiftwj

Location
United Kingdom

Observations

Start time (UT)
22:59:45.7

Duration
10 min

Exposure time
3.971 s

Gain
24.9 dB

Light Curve

Measured Magnitude: 13.6 ± 0.1

17h 36m 57.09s / +14° 58' 31.77" - Aug. 12, 2025 - 23h 05m 23.225
13.0
13.5
14.0
Measured Magnitude
23:03:20
23:06:40
Time

ILLUSTRATION

▲ **We tracked comet C/2025 K1 (ATLAS) for months and saw it brighten and change as it approached the Sun**

Ephemeris files aren't needed for these events: the Unistellar app's deep link provided the telescope with coordinates, capture settings and start/end times to observe our target of choice. We spent a couple of hours observing TOI 6177.01, a Neptune-like exoplanet, and saw its transit detected in our results.

Monitor satellites

The Satellites programme is a new addition to the Unistellar Network and an opportunity to contribute to the study of artificial objects in low Earth orbit (LEO). Over the last 10 years, the number of active LEO satellites has increased to almost 10,000 – and could jump sixfold over the next decade. This congestion is severely disruptive to Earth-based scientific and astronomical imaging, which relies on long exposures and the detection of faint objects. Satellites can also interfere with radio wave detection, which is an essential element in astrophysics research.

By tracking satellites in LEO and submitting observations, users are helping scientists to understand the impact of a growing LEO population on astronomy, while also monitoring how effective modern designs are at reducing disruptive glare.

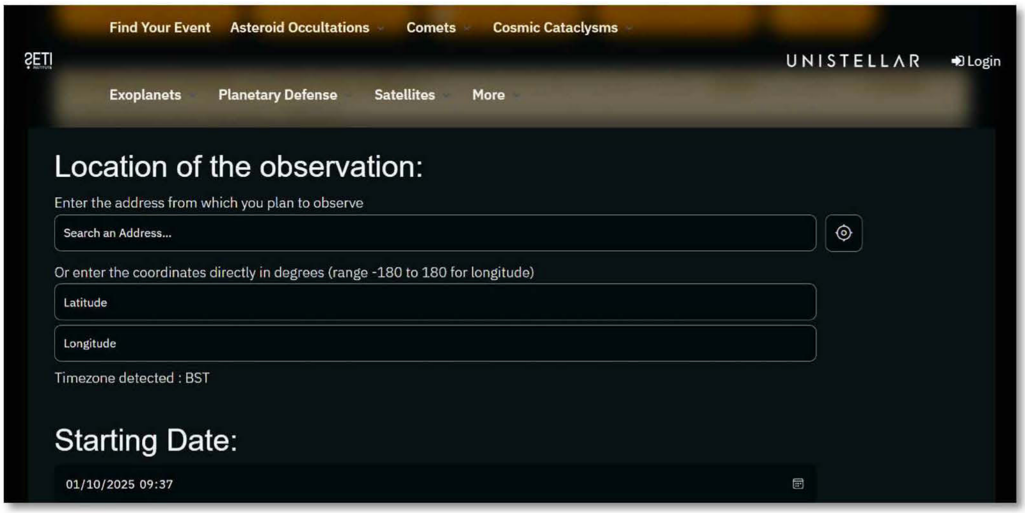
The 'Find Your Event' page is again a great way to find out which satellites you can track from your location for a given date and time, but the 'Missions' page sets out targeted campaigns that the SETI Institute is most interested in collating data on. One example is the Advanced Composite Solar Sail System (ACS3), a NASA experimental satellite that's testing a solar sail. When its sail is unfurled, it increases to 80 square metres (861 square feet) and its magnitude equals the brightest stars in our sky!

Discover a comet

Comets are small objects made of ice and dust which evolve as they get closer to the Sun. Studying these changes helps scientists to understand their behaviour and composition. For example, citizen astronomers captured the fragmentation of comet C/2019 Y4 (ATLAS) back in 2020, providing data on its disintegration and changes in appearance.

This has been quite a year for comets, with the discovery of the third-ever interstellar comet, 3I/ATLAS, and (at the time of writing) C/2025 A6 Lemmon's anticipated rise to naked-eye visibility. As with Planetary Defense, you need ephemeris files to accurately locate a comet, as it's a moving object. The process of selecting an appropriate target and uploading its ephemeris via deep link is very similar. The 'Comet' Slack channel was an exceptionally useful starting point, with scientists regularly posting updated dates for the close approaches of a variety of comets. ▶

▼ **Start from the 'Find Your Event' page to discover what you can spot from your own backyard**



Location of the observation:

Enter the address from which you plan to observe

Search an Address...

Or enter the coordinates directly in degrees (range -180 to 180 for longitude)

Latitude

Longitude

Timezone detected : BST

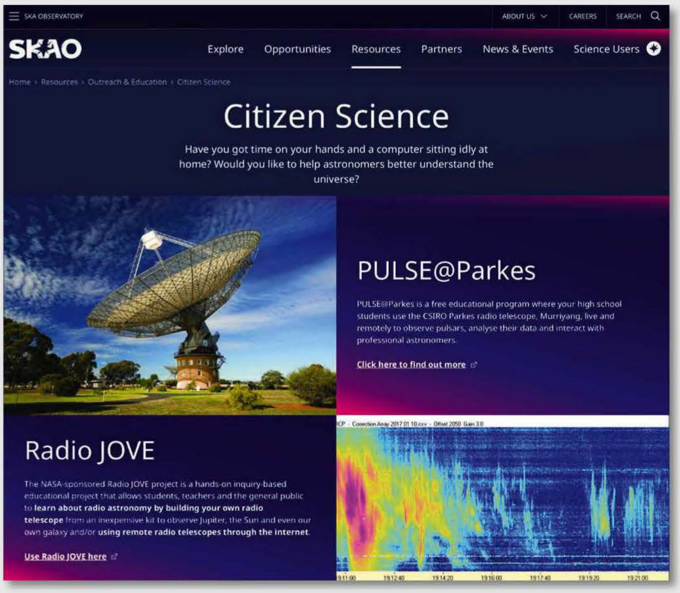
Starting Date:

01/10/2025 09:37

ALL SCREENSHOTS: CHARLIE DANIELS | EXOPLANET TRANSIT ILLUSTRATION: PPRAT, GETTY | COMET ILLUSTRATION: IGORZH, GETTY

Other ways to get involved

Don't have a smart telescope? Don't worry, there are plenty of citizen science astronomy projects you can participate in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Citizen Science

Have you got time on your hands and a computer sitting idly at home? Would you like to help astronomers better understand the universe?

PULSE@Parkes

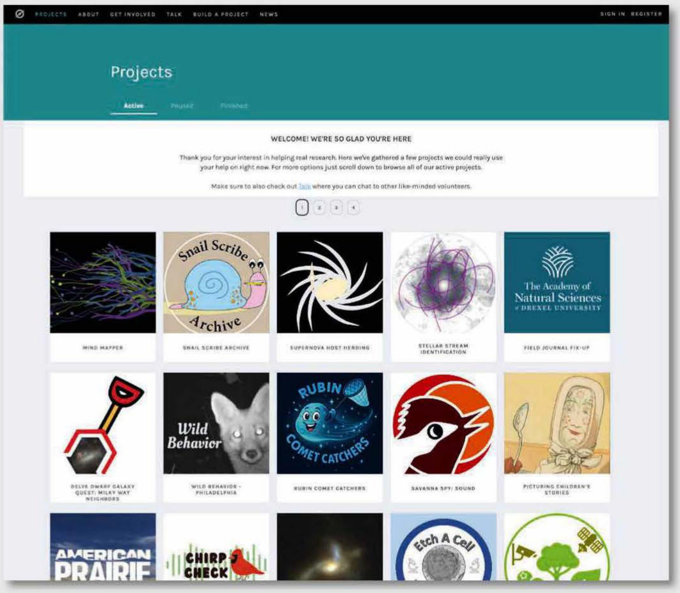
PULSE@Parkes is a free educational program where your high school students use the CSIRO Parkes radio telescope, Murriyang, live and remotely to observe pulsars, analyse their data and interact with professional astronomers.

Click here to find out more

Radio JOVE

The NASA-sponsored Radio JOVE project is a hands-on inquiry-based educational project that allows students, teachers and the general public to **learn about radio astronomy by building your own radio telescope** from an inexpensive kit to observe Jupiter, the Sun and even our own galaxy and/or **using remote radio telescopes through the internet**.

Use Radio JOVE here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Thank you for your interest in helping real research. Here we've gathered a few projects we could really use your help on right now. For more options just scroll down to browse all of our active projects.

Make sure to also check out Talk where you can chat to other like-minded volunteers.

Square Kilometre Array Observatory (SKAO)

www.skao.int /en/resources/outreach-education/citizen-science

The SKAO, an international project to build the world's largest radio telescope arrays, runs several citizen science projects.

PULSE@Parkes is a project especially for students that lets pupils use a CSIRO Parkes radio telescope to observe and analyse pulsar data. **Einstein@Home** uses your computer's idle time to search for weak pulsar signals in data from LIGO gravitational-wave detectors, the MeerKAT radio telescope and Fermi gamma-ray satellite, as well as archive data from Arecibo. Simply download the Einstein@Home software to join a community of over 500,000 volunteers.

Radio Galaxy Zoo: EMU asks you to inspect radio images from the Australian SKA Pathfinder telescope to help identify supermassive black holes and star-forming galaxies. **Gravity Spy** trains LIGO computers to recognise glitches that reduce sensitivity to faint gravitational-wave signals. By going through spectrograms and identifying or classifying glitches, you can increase LIGO's ability to detect these ripples in spacetime.

Zooniverse

www.zooniverse.org/projects

The Zooniverse platform is a hub of citizen science activity, with over 2.5 million registered users providing crucial data across a range of projects. **Supernova Host Herding** is one example, with volunteers studying images of supernovae to identify any that might have occurred from galaxy mergers. You get access to supernovae images from Blast, which is a database containing almost 40,000 examples. Human inspection is vital, as computers currently struggle to identify galaxy mergers because no two events look the same.

Burst Chaser is another classification project, but this time you'll categorise light curves to help identify ultra-energetic gamma-ray burst (GRB) signatures. The physical mechanisms that produce GRBs are believed to be created by highly energetic events, including black hole formation and neutron star mergers. Using data from NASA's Burst and Transient Source Experiment (BATSE) space telescope, you'll be searching for sharp peaks that can signal a GRB eruption.

▶ We turned the Odyssey Pro towards comet C/2025 K1 (ATLAS) several times over August, September and October. Originating from the Oort cloud, this object had a close approach to Earth in August before passing the Sun at a distance of just 0.33 AU in early October. Capturing multiple observations like this allows scientists to track changes in a comet's brightness and appearance throughout its journey.

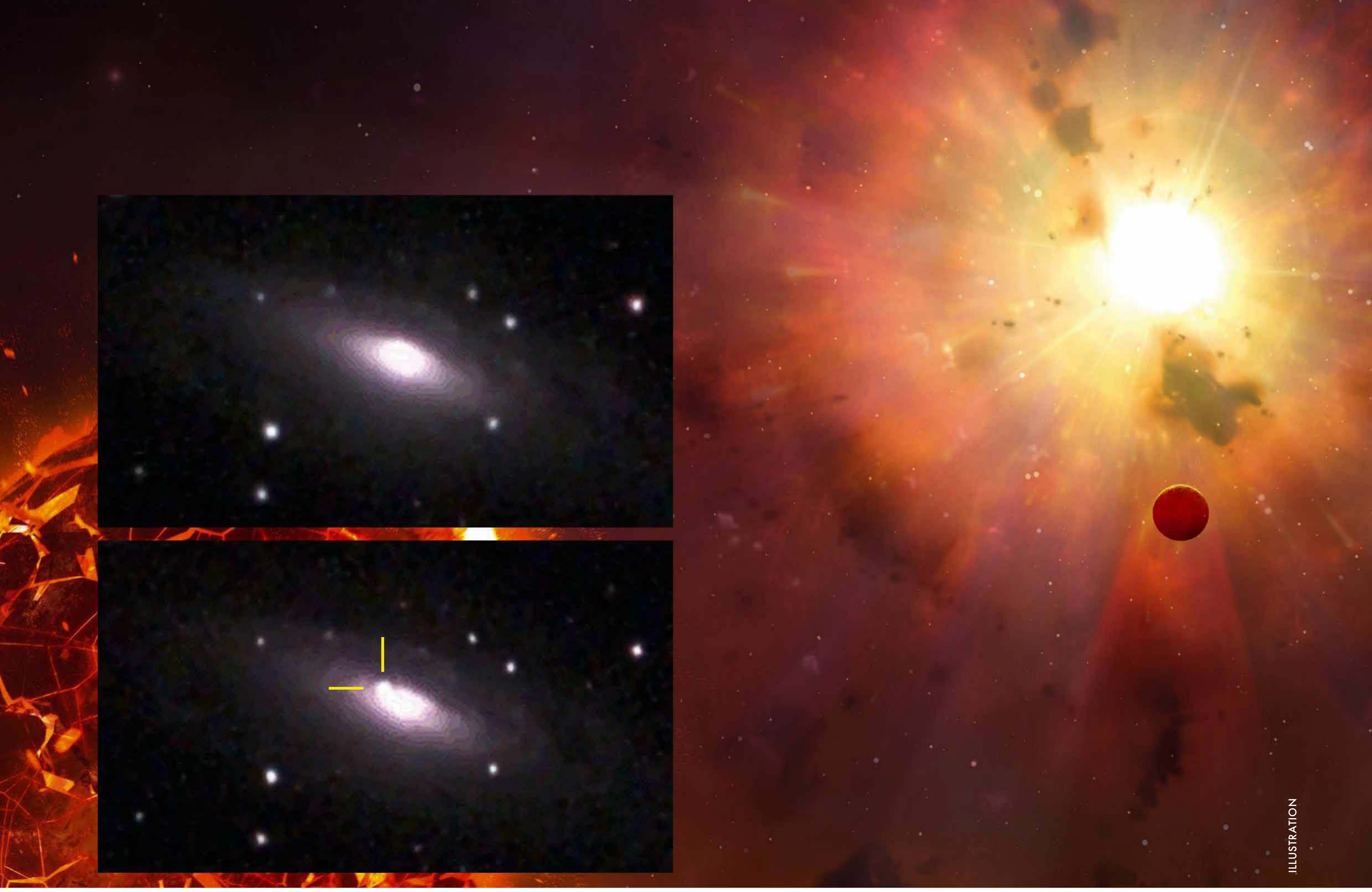
Spot space explosions

Cosmic cataclysms are often unpredictable explosions that are observable for anything from seconds to years, depending on the event. Supernovae are a prime example, but others include gamma-ray bursts (GRBs) and regular 'nova' events, which are explosions on the surface of white dwarves in binary systems.

By tracking the increase or decrease in magnitude of these objects, citizen science data is helping scientists to establish what causes these cataclysms. In 2023, for example, 123 users provided data on a supernova in the Pinwheel Galaxy, M101, within hours of its discovery being announced. The observations continued over 35 days, and the resulting analysis was published in a research note of the American Astronomical Society.

Heading to the Cosmic Cataclysms section of Unistellar's 'Missions' page, we noticed there was an

Charlotte Daniels is *BBC Sky at Night Magazine*'s reviews editor and an experienced astrophotographer and image processor

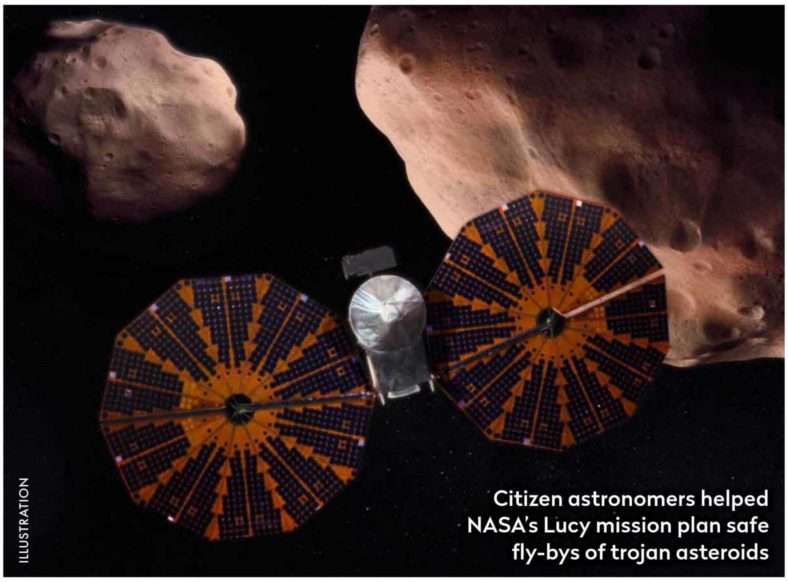


▲ **Several volunteer observers spotted SN 2025RBS, a Type Ia supernova in spiral galaxy NGC 7331, flaring and dimming in July 2025**

> *"In 2023, 123 users provided data on a supernova in the Pinwheel Galaxy within hours of its discovery"*

advisory to make nightly observations of T Coronae Borealis (T CrB), a recurrent nova that is expected to erupt between 2025 and 2026. We observed this target across several nights, uploading our data for processing. The report of our observations showed how these compared to others in the network over the past two years, allowing us to see how the object's brightness is trending. While T CrB had not yet erupted at the time of writing, this could change any night soon!

Not every observation is about catching the explosion itself – a 'non-detection' can be scientifically valuable too. In 2022, gamma-ray telescopes detected an exceptionally bright burst, GRB 221009A. Seven citizen scientists were ready to capture its fleeting optical signature. None succeeded – but this allowed astronomers to put an upper limit on the burst's optical magnitude.



Citizen astronomers helped NASA's Lucy mission plan safe fly-bys of trojan asteroids

Catch asteroid crossings

The final programme covers asteroid occultations, when an asteroid crosses in front of, or 'occults', a distant star, causing the light to flicker as it temporarily blocks the starlight for a matter of seconds. There are plenty of occultations to observe involving asteroids from the main asteroid belt between Jupiter and Mars. These are particularly interesting to scientists, since this is believed to be debris from the formation of our Solar System. Another notable type is a trojan asteroid, which shares its orbit with a planet.

Unistellar Network data has directly informed the NASA Lucy mission, a probe launched in 2021 to visit two main-belt asteroids and six Jupiter trojans. Occultation data collected for these asteroids proved so useful that NASA invited the citizen astronomer involved to attend the mission's launch!

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Falcon 9's successful return to the launchpad in 2015 proved orbital-class boosters could be reused – and sparked a spaceflight revolution

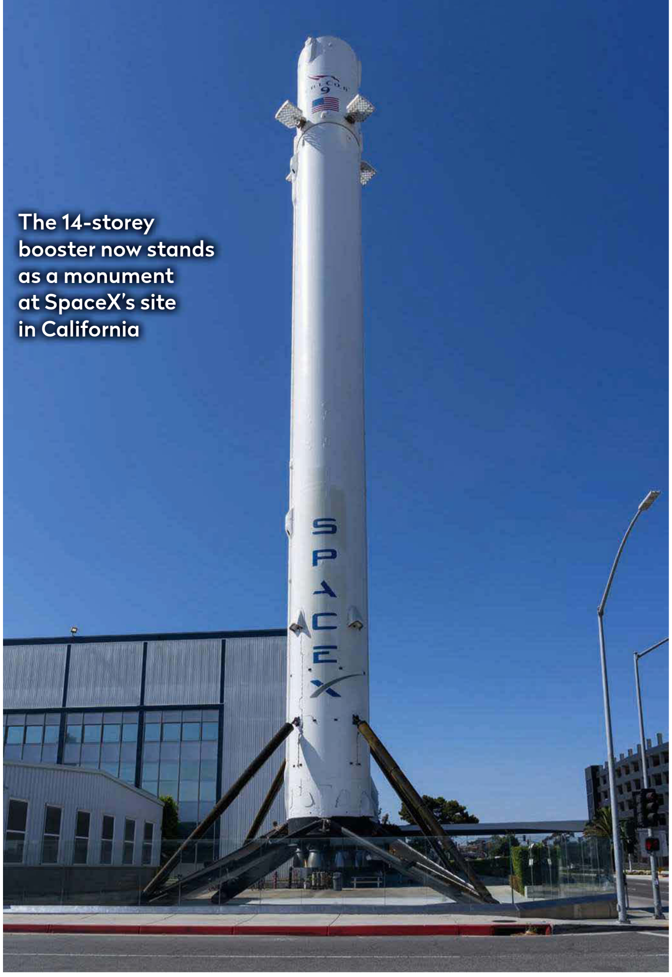
SPACEX

10 years of reusable rockets

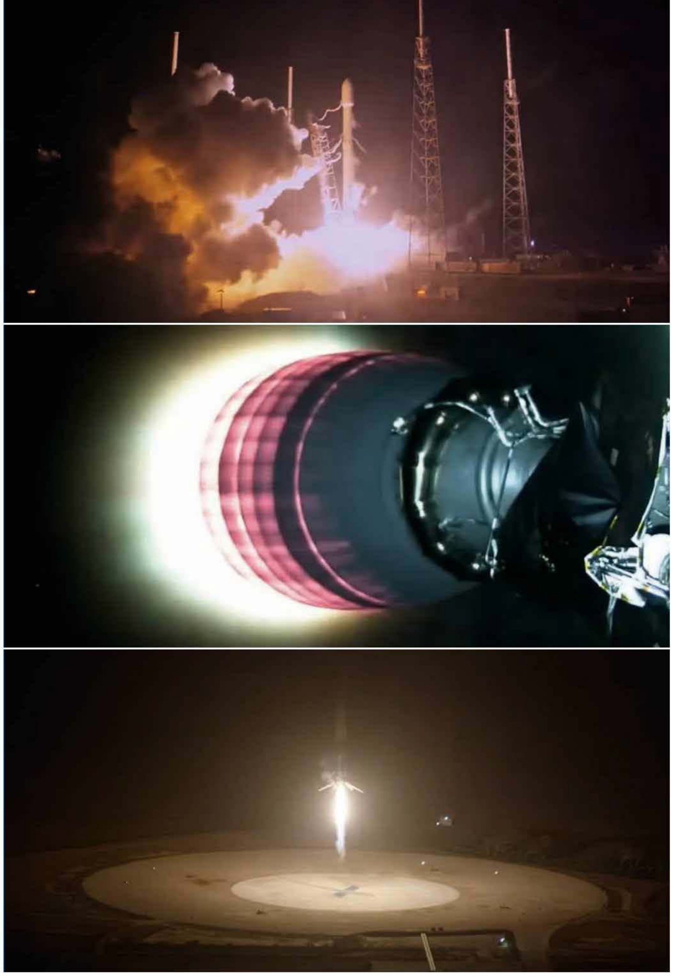
Ben Evans charts the rise of multi-flight spacecraft, the tech revolution that's transforming our access to space

On the intersection of Crenshaw Boulevard and Jack Northrop Avenue in Hawthorne, California, stands an unlikely monument – a modern-day obelisk that bears silent witness to a space revolution. Fourteen storeys tall and partially screened by toughened glass, this SpaceX Falcon 9 was the first orbital-class rocket to launch into space and then return to land intact. Ten years ago, it inspired millions. Today, it inspires even more.

Its nine Merlin engines gleam in the California sunlight. Four aluminium grid fins, like great mechanised ears, helped guide this behemoth back from space to alight on a Cape Canaveral landing pad. And four extendable landing legs, spanning 18 metres (60ft) from tip to tip, recall the night ▶



The 14-storey booster now stands as a monument at SpaceX's site in California



▲ **Touchdown triumph: the 21 December 2015 flight, from launch (top) and stage separation (middle) to landing back on the pad (bottom) after delivering 11 satellites to low Earth orbit**

▶ of 21 December 2015, when it blasted into space, flipped around in mid-flight and roared safely home.

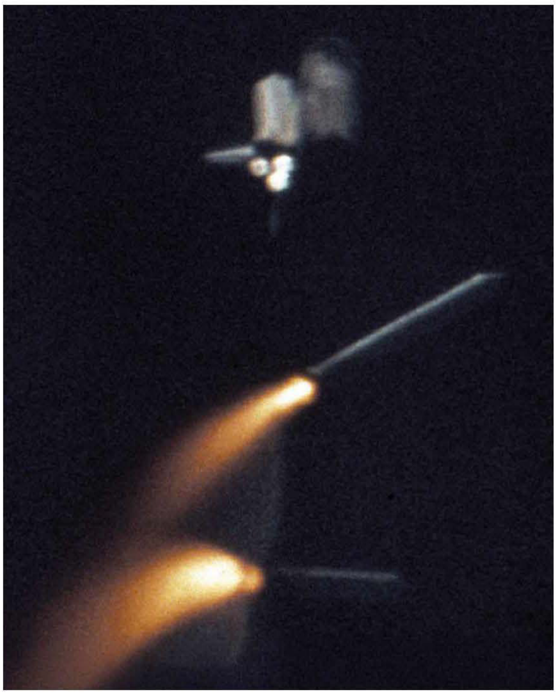
Until that night, 'orbital-class' rockets were discarded after every mission – a lack of reusability that kept the cost of space travel eye-wateringly high. After all, scrapping a brand-new airliner to build a new one after each flight would make air travel prohibitively expensive. But rockets are not airliners. They attain greater energies, reach immense speeds and must withstand tremendous thermal, aerodynamic and structural loads. That demands high levels of reliability and makes them hard to inexpensively reuse.

From Shuttles to SpaceX

Rocket reusability is not new. NASA's partially reusable Space Shuttle flew 135 times between 1981 and 2011. Its fleet of five reusable orbiters – Columbia, Challenger, Discovery, Atlantis and Endeavour – completed multiple missions into low Earth orbit, and its solid-fuelled rocket boosters parachuted into the ocean after each launch and were used again. Only the Shuttle's giant external fuel tank was discarded on each flight.

But the Shuttle's goal to make space access reliable and routine never came to pass, due to its complexity and technical challenges, notably its high-performance main engines and fragile thermal protection tiles. Hopes that individual orbiters would fly 100 times were never realised – even Discovery, the fleet's leader, completed just 39 flights between 1984 and 2011. And the Shuttle never flew more than nine missions in a single year – a far cry from early plans for launches every week.

From the outset, Elon Musk's SpaceX considered rapid rocket reusability as an essential prerequisite for a spacefaring species. Musk opted for a 'powered descent' architecture – that is, using restartable, throttleable engines, landing legs, grid fins to furnish precise aerodynamic control and complex computer algorithms to vertically land boosters with pinpoint accuracy on drone ships at sea or on ground-based landing pads.



◀ **Space Shuttle boosters were jettisoned minutes into a flight and recovered from the ocean for reuse**

But the Falcon 9's early drone-ship landings ended dismally. One booster crashed when its grid fins ran out of hydraulic fluid. Another hit the ship at the wrong angle, toppled over and exploded. With grim humour, Musk called it "rapid unscheduled disassembly". A tongue-in-cheek euphemism,

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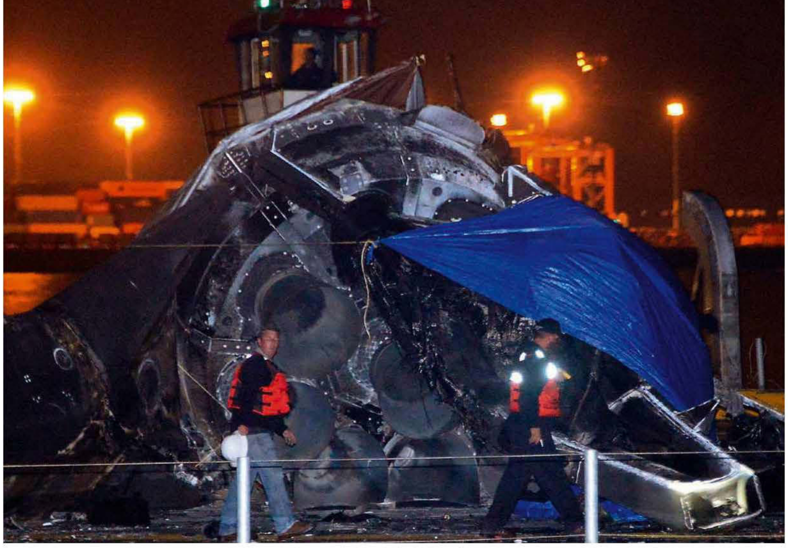


▲ **Wreckage of a Falcon 9 that exploded on a drone ship in 2016 after one of its landing legs failed to lock**

perhaps, but for SpaceX it was an entirely new design philosophy. Earlier rockets were developed to full maturity before their first launch. But Musk's approach was to iteratively test prototypes to the point of failure, learn lessons quickly and aggressively, make improvements, then fly more, test more and learn more.

"The Falcon has landed"

Late in 2015, SpaceX announced plans to land its first Falcon 9 on solid ground. A disused Cape Canaveral launch facility had been rebuilt to form two giant landing pads and, on 18 December, the Federal Aviation Administration (FAA) granted permission for the landing attempt to go ahead. Local residents were warned that they might hear a loud sonic boom as the returning booster decelerated below the speed of sound, seconds before touchdown. And Cape Canaveral workers received safety notices telling them to take shelter away from windows and doors should the landing go awry.

At 8:29pm EDT on 21 December, the Falcon 9 rose from Cape Canaveral's Space Launch Complex 40 atop a pillar of golden flame, casting an eerie glow over Florida's space coast. Eighty seconds into ascent, it exceeded the speed of sound. And after three minutes, at an altitude of 80km (50 miles), right on the edge of space, the Merlin engines shut down right on time and the rocket's first and second stages parted company.

For its first stage booster, the moment of truth had arrived. Travelling at 4,600km/h (2,900mph), under aerodynamic conditions comparable to balancing a broomstick in the palm of your hand during a fierce storm, the Merlins ignited three times to reverse course back to Florida, flip around and decelerate to a landing speed of 7.2km/h (4.5mph).

Moments before touchdown, the booster's landing legs unfurled, and at 8:38pm it fell gently onto the concrete pad. The last glimmer of flame from its engines flickered for a second or two, then fell dark. "The Falcon has landed," exulted the SpaceX commentator to an online audience of millions.

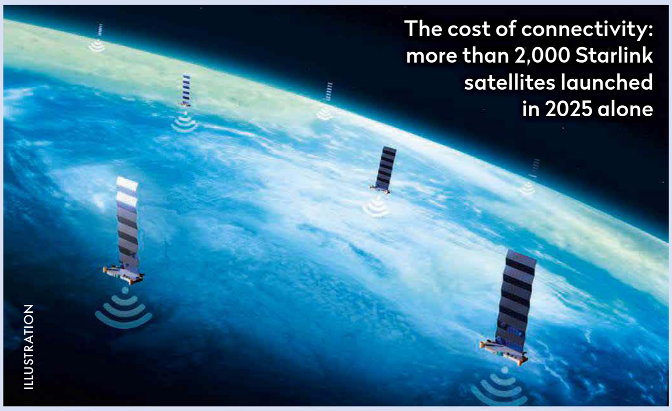
Success was triumphantly accomplished in under 10 minutes. After the flight, the booster was inspected, refuelled and test-fired to see if future ▶

The downside of reusable rockets

Congested skies are the price we pay for easier, cheaper hops into space

At first glance, the benefits of rocket reusability and sustained access to space are self-evident: advancing our path to becoming a spacefaring species. But with a far higher rocket launch rate than ever before, serious concerns have arisen about the wisdom and potential impacts of new and emerging space markets.

Take 'mega-constellations' of small internet satellites, like SpaceX's Starlink network, launched in batches by the Falcon 9 since 2019. More than 9,700 Starlinks have been put in space – including over 2,000 in 2025 alone. That adds to an already cluttered low Earth orbit environment that has irked the astronomical community with its impact on light pollution.

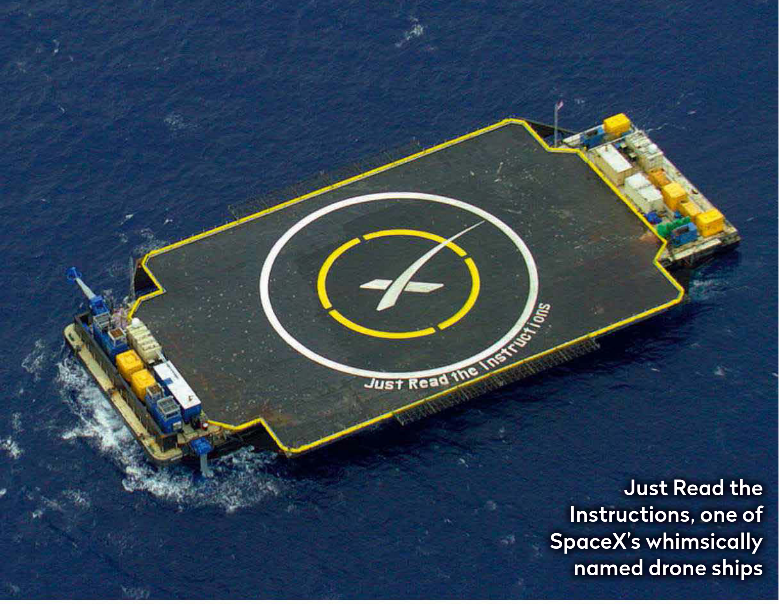


The cost of connectivity: more than 2,000 Starlink satellites launched in 2025 alone

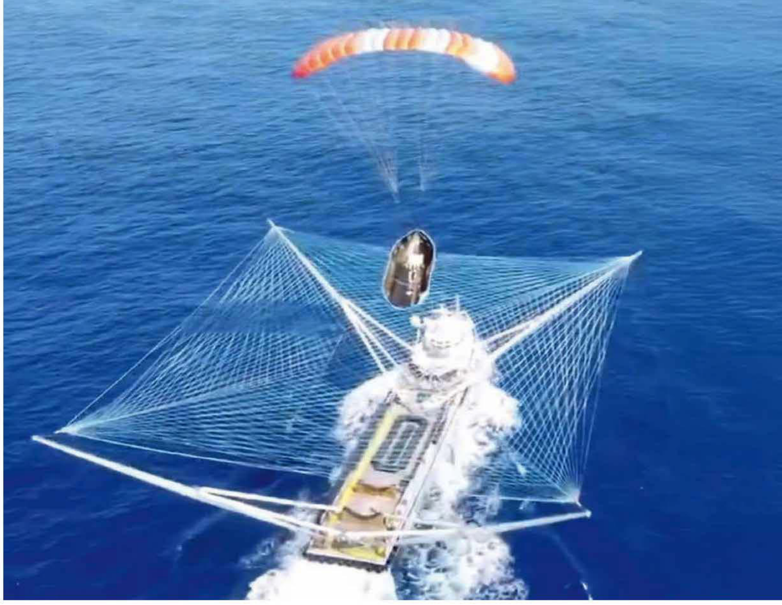
ILLUSTRATION

The risks from worsening space debris are substantial. In 2023, Falcon 9 rockets put 1.2 million kg (2.6 million pounds) of payload into orbit; last year, that figure rose to 1.5 million kg (3.3 million pounds). That poses a significant hazard to other satellites and to human space missions that operate in the low Earth orbit domain. The looming retirement of the International Space Station has a group of private entities – from AxiomSpace and Vast to Blue Origin and Sierra Space – waiting in the wings to assemble large private space stations before 2030, all of which will benefit from the lower costs offered by reusable launch vehicles.

And coupled with Blue Origin's New Shepard having generated over $100 million in space tourism, these lucrative markets will inevitably expand as launch prices fall and demand increases, congesting near-Earth space like never before. A Pandora's box in space has opened and its consequences, good or ill, remain to be seen.



Just Read the Instructions, one of SpaceX's whimsically named drone ships



▲ Recovering the fairing (which protects mission payloads) with a giant net on a moving ship

▶ rockets could also handle multiple launches. But this particular booster had savoured its first – and last – taste of space. Retired from duty, in August 2016 it was trucked from Florida to California, cleaned and then craned upright outside SpaceX's headquarters in Hawthorne.

From rare feat to routine

Ten years on, Falcon 9s have landed safely over 500 times, including 400+ drone-ship landings since 2016. SpaceX typically uses drone ships to recover boosters from heavyweight or high-orbit missions, and landing pads for low-weight, low-orbit flights. But success did not come easily. Thirteen landings failed due to low fuel, incorrect wind-speed data or engine problems – most recently in March 2025. Two boosters landed on the drone ship only to be later lost due to high winds and foul seas during their transit back to port. And in 2018, a booster missed the landing pad and landed in the water.

Improvements over the years, including retractable, self-levelling landing legs for rapid recovery and more durable titanium (rather than aluminium) for grid fins, brought greater reliability. Higher-thrust engines streamlined refurbishment. All this enabled launch rates to soar from six missions in 2015 to missions every two weeks by 2020, to a marathon 134 flights – a mission every two days, on average – last year.

Since 2017, over 50 boosters have flown at least twice. Today, 23 boosters are in active operational service, each capable of 10 flights with minor upgrades and 100 flights with periodic repairs. A booster flew a record 30th time in August 2025. Turnaround times improved, with one booster flying twice in nine days in March 2025. And intervals between missions also improved: from two launches in a month in 2014 to two launches in a day in 2021, to two launches just 65 minutes apart in August 2024.

Unsurprisingly, in terms of flight rate, SpaceX is in a league of its own among launch providers. In 2020,

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Reusability by the numbers

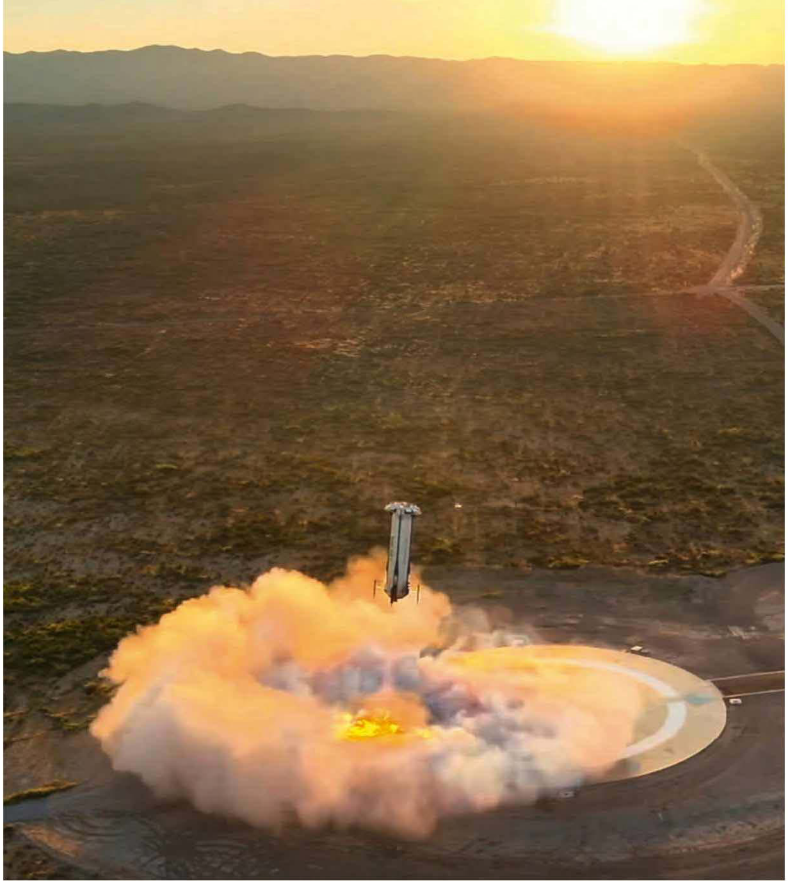
How much money is actually saved by recycling spacecraft?

In 2024, SpaceX was responsible for just over half of the world's orbital launches, a market share that's expected to climb above 60 per cent by the end of 2025. And with a cost of $2,750 per kilogram on a reused Falcon 9, this most-flown booster in US history sits head and shoulders above any other launch service provider in the world.

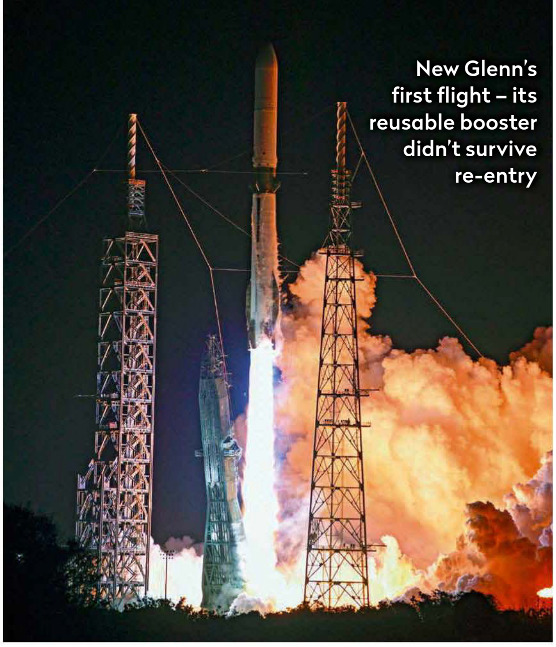
Other rockets struggle to compete with SpaceX's proven reusability and high launch cadence. The now-retired Shuttle averaged $54,400/kg, ULA's Atlas V and Vulcan may reach $9,800/kg and Blue Origin's New Glenn promises launch prices of just $1,500/kg. SpaceX believes its giant Starship vehicle may achieve costs as low as $250–$600/kg when it becomes fully operational.

Since first stages and payload fairings constitute 80 per cent of the expense of a Falcon 9 launch, their recovery and routine reuse crucially keeps costs low. Since 2017, SpaceX has actively recovered first stage boosters, and since 2019 has regularly retrieved and reused fairings. In 2025, a booster flew a record 30th time and a fairing achieved a 33rd flight, helping the Falcon 9 retain its top spot as the most cost-effective launch vehicle in the world.

Return to sender: a Falcon 9 being prepared for reuse at Port Canaveral in Florida



▲ Blue Origin has successfully landed its reusable New Shepard boosters dozens of times



New Glenn's first flight – its reusable booster didn't survive re-entry

Mechanical 'chopstick' arms catch Starship's returning Super Heavy booster

Falcon 9s flew one fifth of all orbital missions. By 2024, that had risen to half. This year, Musk should seize about 60 per cent of the world's launch market.

SpaceX has also reused the Falcon 9's payload fairings since 2019, initially salvaging them with ship-based nets, then since 2021 scooping them directly from the water. In September 2025, one fairing launched a record 33rd time.

Everyone wants in

But SpaceX is not alone in this rocket reusability market. Blue Origin's fully reusable New Shepard suborbital boosters and crew capsules have flown 35 times since 2015, carrying science experiments, postcards and fare-paying human passengers to the edge of space. Its boosters land vertically under their own power, while crew capsules descend by parachute, with turnaround times as short as 59 days.

In 2025, Blue Origin launched its orbital-class New Glenn rocket for the first time; its first stage will be recovered by the company's Jacklyn barge on future missions. Rocket Lab's Neutron booster will also land on a floating platform. China's Tianlong-3, designed for up to 10 flights, will make vertical touchdowns on drone ships or ground pads. And in 2024, a prototype of China's Zhuque-3 rocket climbed to 10km (6.2 miles) before making a controlled vertical landing.

Russia's upcoming Amur rocket will feature grid fins and landing legs for reusability, as will Europe's Miura-5 and Maia boosters, scheduled to come online in 2027. Two years ago, Relativity Space's 3D-printed Terran-R rocket completed a short, low-altitude flight to test control systems, ascending to 10 metres (30ft) before performing a vertical landing.

United Launch Alliance's (ULA) Vulcan booster, first launched in 2024, will feature a reusable engine suite: its entire propulsion system will detach after engine cutoff, then parachute to a water landing for recovery and reuse. ULA anticipates this will cut Vulcan's propulsion system costs by 90 per cent and its first stage costs by 65 per cent.

Rocket Lab's Electron booster – flown 70 times since 2018 – achieved its first controlled re-entry in 2019 and its first parachute-aided splashdown in 2021. One of its Rutherford engines from a May 2022 mission was refurbished and used on another flight in August 2023.

Meanwhile, SpaceX's fully reusable Starship, which has completed 10 test flights since 2023, promises to lift enormous payloads into low Earth orbit, deliver cargo to the Moon and Mars, and potentially carry hundreds of people into space on a single launch. But its genesis has been troubled with fuel leaks, explosions, controllability issues and engine failures.

In October 2025, however, both Starship and its Super Heavy first stage successfully completed a test flight, with both components making a controlled descent. But this may be too little, too late, as NASA has expressed concerns about SpaceX falling behind schedule and, in response, has reopened bidding for its lunar lander contract.

Despite this, there's no doubt that rocket reusability has advanced at breathtaking speed over the last decade and has been far-reaching in its potential. And with other players waiting in the wings to ensure this new era of space exploration is no one-horse race run solely by SpaceX, the coming decade holds great promise as humanity prepares to occupy low Earth orbit and venture to the Moon, Mars and beyond.

Ben Evans is the author of several books on human spaceflight and a science and astronomy writer

The fundamentals of astronomy for beginners

EXPLAINER

'Twinkle, Twinkle Little Distortion' isn't as catchy – but that's exactly why stars like Sirius shimmer

Why do stars twinkle?

Find out how starlight that's steady in space seems to sparkle from Earth

All stars appear to twinkle, so it may surprise you to learn that actually... they don't. After all, we all know the English lullaby, 'Twinkle, Twinkle Little Star' from Jane Taylor's 1806 poem 'The Star'. So why does it happen, and what exactly is 'twinkling'?

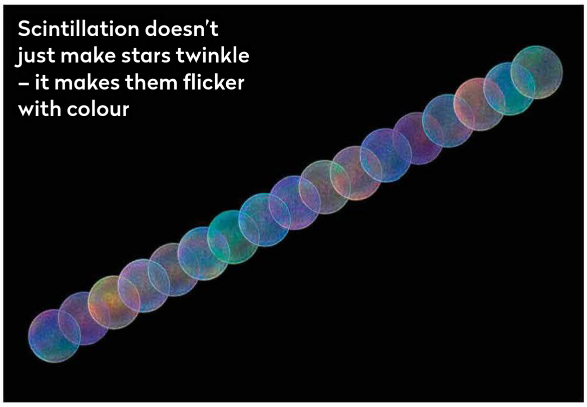
In the vacuum of space, stars do not twinkle. Starlight is stable and unblinking. Twinkling – scientifically known as atmospheric scintillation – only happens when stars are viewed from Earth, and refers to the rapid, miniscule changes in their apparent position, brightness and colour. It's caused by turbulence in our planet's atmosphere, which reaches about 10,000km (6,200 miles) above its surface.

Air is not static. It moves constantly under the influence of various forces. Warm air masses rise from the ground, are heated by the Sun and spread into the cold upper realms. These eddies create turbulence of varying temperatures and densities, pockets of hot and cold air that act like lenses. When starlight navigates these currents, the 'lenses' continually bend (refract) it in random directions, manifested as the sparkling and blinking we see. It resembles how objects seem to sway and distort when seen through heat rising off a hot tarmac road, known as terrestrial scintillation. Rather than travelling directly to your retina, the light zigzags.

These turbulent pockets of air also make starlight pulsate in and out of focus as rays alternately diverge and converge, like sunlight quivering across rippling water. They also disperse the light like a prism into a spectrum of rainbow colours. Differing wavelengths of light determine the different routes taken through the air.

Why weather matters

Climate and weather conditions also influence the twinkle intensity. Humid,



Scintillation doesn't just make stars twinkle – it makes them flicker with colour

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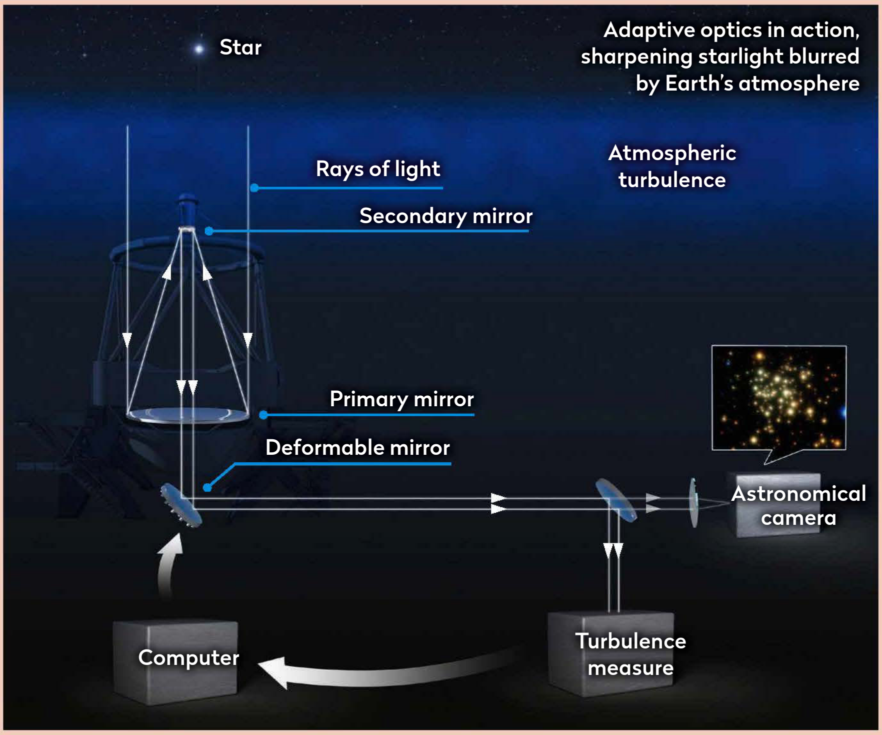
How telescopes beat the blink

Twinkling is distortion – and that's a problem for astronomers. Here's how they fix it



Twinkling is a joy for poets, but not so much for those seeking pristine images, such as astrophotographers and professional astronomers.

To overcome atmospheric distortions, scientists operate telescopes – such as the venerable Hubble Space Telescope and, more recently, the James Webb Space Telescope – above Earth's atmosphere. In the vacuum of space, starlight travels unimpeded in a straight, consistent path to telescope mirrors, resulting in super-sharp pictures of non-twinkling celestial objects.

But on the ground, large reflector telescopes compensate by using adaptive optics (AO) technology. At its core is a deformable mirror, a separate unit positioned after the light has been reflected from the primary mirror. One or more wavefront sensors rapidly measure the distorted wavefront of the light entering the telescope. Once the distortions have been measured – aided by a reference source such as a star or sky-pointing 'artificial' laser beacon – a real-time control system calculates and sends corrective signals to the actuators on the deformable mirror. It then changes shape hundreds or even thousands of times a second to cancel out any aberrations.

Experimental liquid crystal (LC) arrays are also now being developed, which offer a potentially cheaper and more accurate solution. They dynamically correct distortions in real time by altering the phase of the light passing through them.

dense air makes starlight shimmer strongly. Still air in a dry area appears more stable. Twinkling is particularly apparent on windy and frosty nights, and in summer can presage an approaching storm.

High and dry: Chile's mountaintops offer the steady skies that astronomers need

The extent to which astronomical targets appear to shimmer and shake is known as 'seeing'. Thick air creates more scintillation – 'bad seeing' – and thin, dry, steady air affords 'good seeing'. That's why ground-based astronomical observatories are sited at high-altitude, arid locations, minimising the air – and thus the interference – between them and the stars.

The longer the journey that starlight makes through Earth's atmosphere – when viewing stars closer to the horizon rather than directly overhead – the denser the atmospheric currents and the more pronounced the twinkle. Vice versa: at the zenith, twinkling is less pronounced – the atmosphere is thinner and the optical effects are reduced. The more agitated the air and the brighter the star, the more light is bent and the more noticeable the scintillation.

Do planets twinkle?

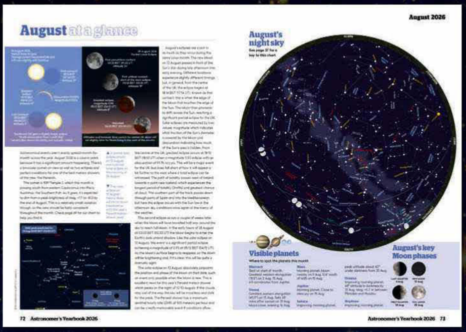
Planets are much closer to Earth, appearing as luminous discs rather than distant tiny dots. Lacking thermonuclear reactions, they don't emit their own light but reflect starlight, which enters our atmosphere as a thicker beam of light. Multiple rays reach our eyes, and while each ray is bent by turbulence, the overall effect is averaged out. Since they're located near the ecliptic and shine with a steady light, they're easier to identify.

Sirius (Alpha Canis Majoris), the brightest star in the sky, sparkles spectacularly. Why? Firstly, it has twice the mass of our Sun and is 25 times more luminous. Secondly, it's just 8.6 lightyears away. This extreme proximity, coupled with its intrinsic brightness, amplifies atmospheric effects; it appears to rapidly change colour – red, yellow, green, blue and white – several times per second (atmospheric scintillation). Thirdly, it often sits near the horizon, where we see it through a denser part of Earth's atmosphere, filled with particles like sea salt, dust, pollen, spores, volcanic ash and soot. The thicker the atmosphere, the greater the perturbations and the more changes in colour.

Jane Green is an astronomer, presenter and author of the *Haynes Astronomy Manual*

FROM THE MAKERS OF BBC Sky at Night MAGAZINE

The Astronomer's Yearbook 2026



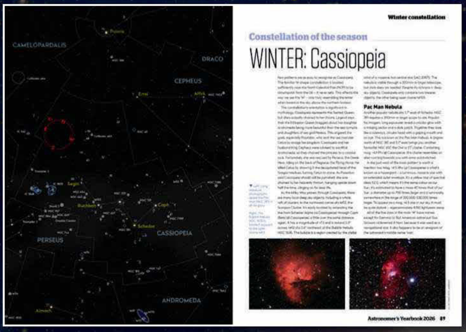
August at a glance

August's night sky

Visible planets

August's key Moon phases

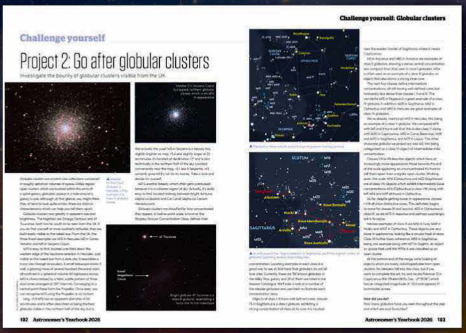
Our month-by-month guide and detailed star charts reveal what to look for and when, from stars and planets to Moon phases and more



Constellation of the season

WINTER: Cassiopeia

Get to know the stand-out constellations of each season, as we highlight their brightest targets and how to best observe them



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The Sky Guide

DECEMBER 2025

GEMINIDS 2025

The wonderful Geminid meteor shower reaches its peak mid-month, with virtually no Moon to spoil the show

HEAD HUNTER

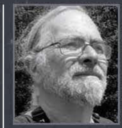
Six deep-sky gems to discover above Orion

CHASING SHADOWS

Track the strange nebula that can't stop flickering

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four


Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month…

- 24P/Schaumasse brightens
- Callisto shadow transit
- Regulus occulted
- 16 Psyche at opposition
- Ursid meteor shower

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

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DECEMBER HIGHLIGHTS

Your guide to the night sky this month

Tuesday

2 Ganymede's shadow crosses Jupiter's disc between 06:11 and 09:26 UT this morning. The event ends under daylight conditions.

Thursday ▶

4 The 98%-lit waxing gibbous Moon occults the Pleiades from around 03:00 UT. Uranus is 4.6° south of the Moon at this time.

Today's Moon is full at 23:14 UT, around 12 hours after perigee, making this a perigee full Moon.

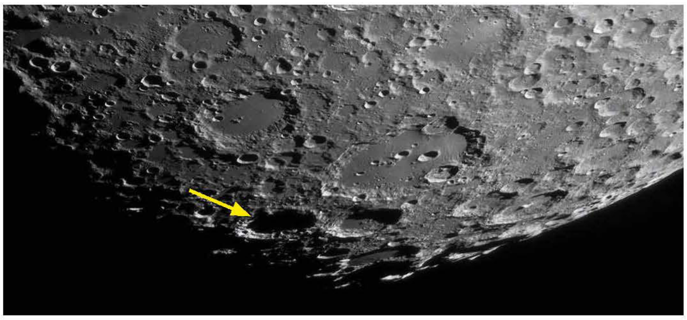
◀ Monday

8 Saturn's largest moon Titan transits the planet's globe this evening between 17:38 and 23:58 UT.

Callisto begins to transit Jupiter's disc between 02:11 and 06:20 UT.

Friday

12 Ganymede is eclipsed by Jupiter's shadow from 23:54 UT this evening, reappearing at 05:59 UT on 13 December.



◀ Saturday

13 There's an optimum opportunity this evening to spot this month's Moonwatch feature (see page 52), the crater Scheiner. If you're clouded out, there's another chance on 29 December.

Tuesday

16 Titan is occulted by Saturn's globe at 16:23 UT, reappearing from occultation at 22:05 UT.

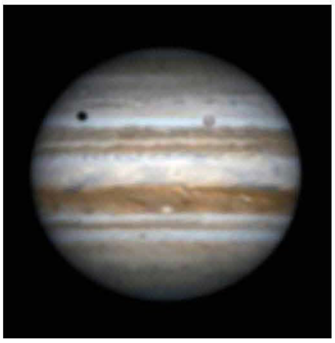
Callisto is occulted by Jupiter at 07:44 UT. Later, Ganymede will transit the planet between its rise at around 18:00 UT and 19:50 UT.

Sunday ▶

21 The December solstice occurs today, the Sun reaching its most southerly position against the background stars.

Tuesday ▶

23 The shadow of Ganymede transits Jupiter's disc between 19:49 and 23:09 UT. Ganymede itself transits at 21:21–23:09 UT.



Wednesday

24 Titan transits Saturn between 16:26 and 23:06 UT.

Io, Callisto and Io's shadow will all be in transit as Jupiter rises.

Friday

26 This evening's 39%-lit waxing crescent Moon sits slightly less than 3.7° from Saturn.

PETE LAWRENCE X 8

Saturday

6 Jupiter's largest moon Ganymede can be seen reappearing from behind the planet's disc from around 02:35 UT.

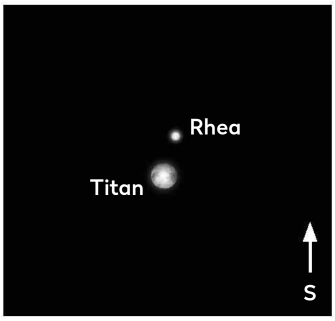
Sunday ▶

7 Mercury (pictured) reaches greatest western elongation today, located 20.7° west of the Sun in the morning sky.

This evening's 87%-lit waning gibbous Moon sits 3.5° from mag. –2.4 Jupiter at around 19:00 UT.

Tuesday ▶

9 A view of low-altitude Saturn at 23:48 UT reveals moons Titan and Rhea are less than one arcsecond apart.



Wednesday

10 Bright mag. +1.3 Regulus (Alpha (α) Leonis) is occulted by the 66%-lit waning gibbous Moon this morning around 07:18 UT under conditions of brightening dawn twilight.

Sunday ▶

14 Today sees the peak of the annual Geminid meteor shower. A reliable performer, this year's display will have minimal interference from the Moon, which will be in its waning crescent phase at the shower's peak.

Monday

22 This evening sees the peak of the annual Ursid meteor shower, well-timed to occur with the young crescent Moon setting in the early evening.

Tuesday

30 Ganymede's shadow crosses Jupiter's disc between 21:59 UT tonight and 01:24 UT on 31 December. Ganymede itself crosses between 23:02 UT tonight and 02:28 UT on 31 December.

Family stargazing

Asterisms are star patterns that aren't official constellations. They come in all shapes and sizes, from tiny ones that need telescopes to see, to huge ones that include stars from several constellations. The largest of all is the Winter Hexagon. Tracing it out in the sky is a great way to get to know several distinctive winter constellations and their main stars. The pattern is formed by drawing a line from Sirius, through Procyon, Pollux, Capella, Aldebaran, Rigel and back to Sirius. We've marked it on our all-sky chart on pages 50–51. **www.bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly Objects marked with this icon are perfect for showing to children

Naked eye Allow 20 minutes for your eyes to become dark-adapted

Photo opp Use a CCD, planetary camera or standard DSLR

Binoculars 10x50 recommended

Small/ medium scope Reflector/SCT under 6 inches, refractor under 4 inches

Large scope Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit bit.ly/stargazing-top-tips to learn how to stargaze in 12 easy steps and bit.ly/choose-first-telescope for advice on choosing your first scope

THE BIG THREE

The top sights to observe or image this month

DON'T MISS

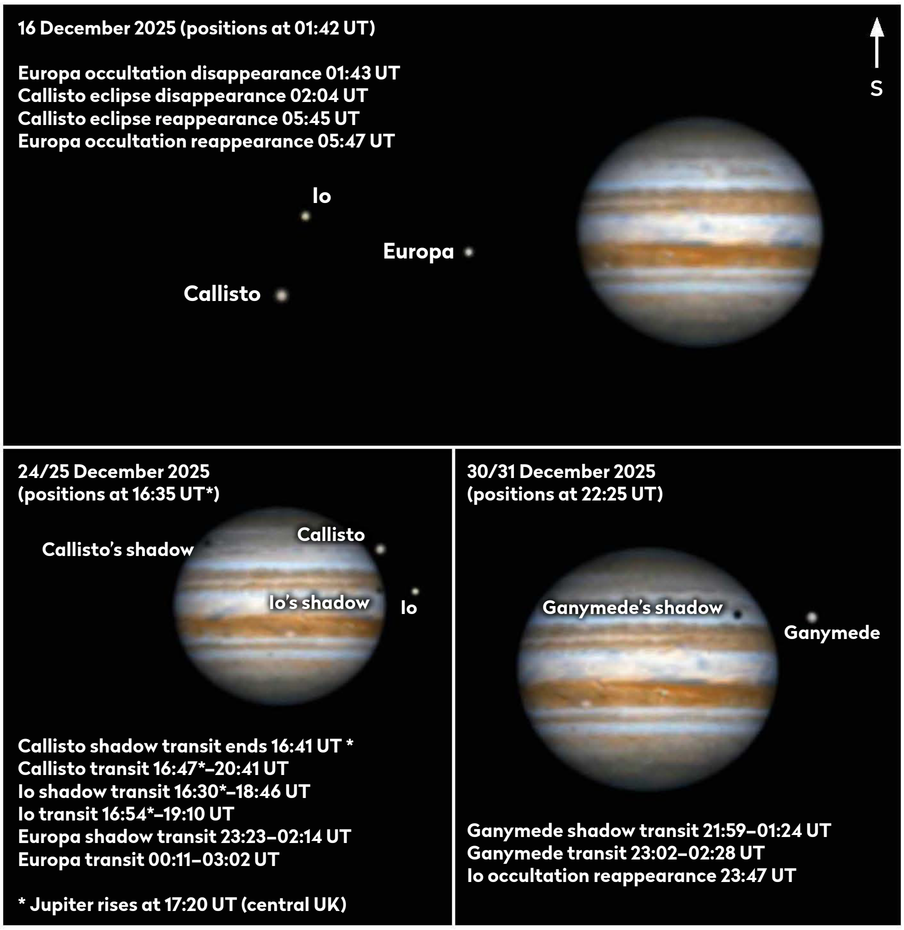
Callisto events

BEST TIME TO SEE: As shown

Jupiter is heading towards an equinox. This is when the planet's alignment with the Sun is such that the Sun appears to cross its equatorial plane. Earth has two equinoxes every year, one in late March and one in late September. Jupiter's year is a little longer – equivalent to 11.9 Earth years – and so its equinoxes are further apart, occurring approximately every six years.

Jupiter's axial tilt is quite small at just 3.1°, but the time around a Jovian equinox is still special, allowing a number of unusual mutual events to occur between its largest moons. In addition, Callisto's orbit appears edge-on enough for the moon and its shadow to start interacting with Jupiter's disc. If you're an avid Jupiter watcher, you'll already be aware that Io, Europa and Ganymede regularly undergo such interactions. However, despite all four moons having roughly equatorially aligned orbits, Jupiter's narrow tilt, combined with the large diameter of Callisto's orbit, means the moon typically misses the planet when it passes close by.

This is not the case now though, as the approaching equinox has narrowed the apparent ellipse of Callisto's orbit sufficiently for the moon to be able to cross Jupiter's globe in a transit event, cast a shadow on Jupiter's globe in a shadow transit event, be hidden by Jupiter in an occultation event and pass into Jupiter's shadow in an eclipse event.



16 December 2025 (positions at 01:42 UT)

Europa occultation disappearance 01:43 UT
Callisto eclipse disappearance 02:04 UT
Callisto eclipse reappearance 05:45 UT
Europa occultation reappearance 05:47 UT

24/25 December 2025 (positions at 16:35 UT*)

Callisto shadow transit ends 16:41 UT *
Callisto transit 16:47*–20:41 UT
Io shadow transit 16:30*–18:46 UT
Io transit 16:54*–19:10 UT
Europa shadow transit 23:23–02:14 UT
Europa transit 00:11–03:02 UT

* Jupiter rises at 17:20 UT (central UK)

30/31 December 2025 (positions at 22:25 UT)

Ganymede shadow transit 21:59–01:24 UT
Ganymede transit 23:02–02:28 UT
Io occultation reappearance 23:47 UT

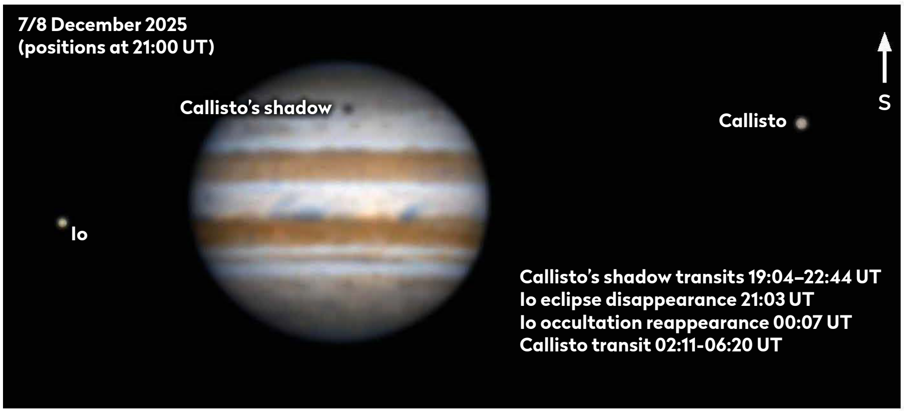
▲ Transits, occultations, eclipses and more: Jupiter's moons put on a great show during December. Note that some of the events on 24/25 December won't be visible from the UK

Seeing these requires good timing: the planet needs to be positioned above the horizon when it's reasonably dark. In addition, we have to deal with the UK's winter weather, which means a degree of persistence will be required.

If you do get clear weather, you'll be able to see Callisto's shadow in transit on the night of 7 December, an event that precedes Callisto itself crossing the planet in the early hours of 8 December. The large 1.88-million-kilometre separation between Jupiter and Callisto often means there are significant time gaps between such events.

On 16 December, Callisto is eclipsed by Jupiter's shadow at 02:04–05:45 UT, then occulted by Jupiter around 07:44 UT. Then on 24 December, Io, Callisto and Io's shadow can be seen in transit in the early evening as Jupiter is rising, with Europa's shadow following suit from 23:23 UT.

Not to be left out, there are also some excellent Ganymede-related events to look out for this month too. Being such a large moon, Ganymede's shadow is always impressive to watch as it passes across Jupiter's disc, as it will to welcome in the New Year on the night of 30/31 December between 21:59 and 01:24 UT.



7/8 December 2025 (positions at 21:00 UT)

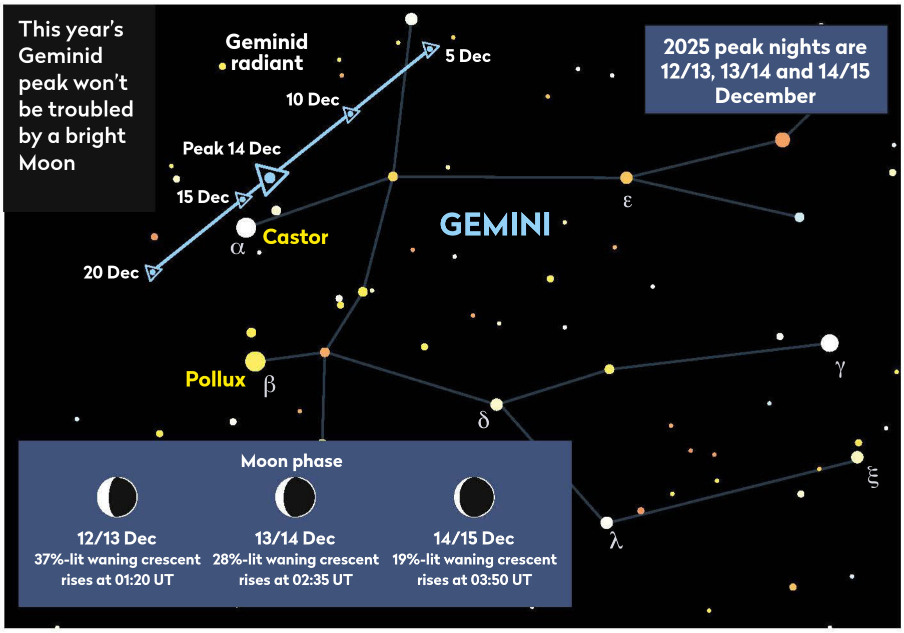
Callisto's shadow transits 19:04–22:44 UT
Io eclipse disappearance 21:03 UT
Io occultation reappearance 00:07 UT
Callisto transit 02:11–06:20 UT

▲ An infrequent opportunity: Jupiter's approaching equinox allows us to see Callisto's shadow cross the planet on the night of 7 December, followed by the moon itself

ALL PICTURES: PETE LAWRENCE

Geminids 2025

BEST TIME TO SEE: 8–16 December, peak night is 13/14 December


Geminid radiant
5 Dec
10 Dec
Peak 14 Dec
15 Dec
20 Dec
Castor
α
GEMINI
ε
Pollux
β
δ
γ
ξ
λ

This year's Geminid peak won't be troubled by a bright Moon

2025 peak nights are 12/13, 13/14 and 14/15 December

Moon phase

12/13 Dec	13/14 Dec	14/15 Dec
37%-lit waning crescent	28%-lit waning crescent	19%-lit waning crescent
rises at 01:20 UT	rises at 02:35 UT	rises at 03:50 UT

The annual Geminid meteor shower reaches peak activity towards the middle of December. This is a rich shower with a peak zenithal hourly rate (ZHR) of 150 meteors per hour. It's a wonderful one to observe if you have clear, dark skies, as the radiant – close to the star Castor (Alpha (α) Geminorum) – rides high across the December sky. A meteor shower's radiant position is the area of sky from which its meteors appear to emanate.

The Geminids are active 4–17 December, but rates are typically fairly low across much of this period. It's only when you get within days of the predicted peak that activity increases significantly. This year's peak is predicted to occur at 08:00 UT on 14 December, meaning you should have a decent chance of seeing a Geminid between 8 and 16 December.

Of course, the darker your sky the better, and here the natural light pollution from the Moon will have an effect. This affects all meteor showers and varies in interference levels from one year to the next. For 2025, the Moon will be past its last quarter phase as it appears in the early morning sky around the time of the Geminid peak, so moonlight interference should be relatively limited.

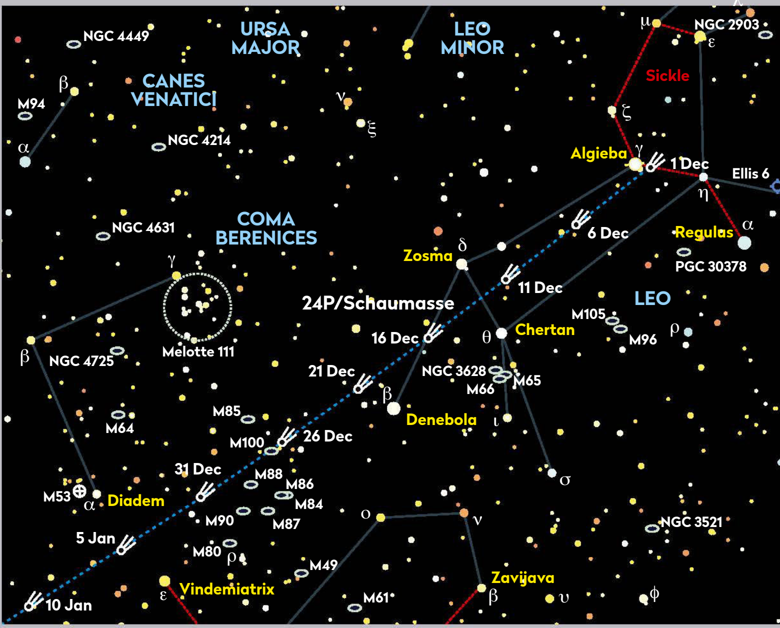
Another major plus for the Geminids is the length of December nights. Unlike the summer Perseid shower, which peaks around 12 August with around 4.5 hours of darkness, the Geminid shower can be enjoyed under dark-sky conditions for around 12 hours. Just remember to wrap up warm! Turn to page 76 for details on how to image Geminid meteor trails.

Comet 24P/Schaumasse brightens

BEST TIME TO SEE: Before dawn at the end of the month

Comet 24P/Schaumasse is a brightening comet best seen in the morning sky during December. On the morning of 1 December, find it near the star Algieba (Gamma (γ) Leonis). It then tracks across the body and tail of Leo throughout the month, passing north of Denebola (Beta (β) Leonis) on the night of 18/19 December. A few days after this, it enters the constellation of Coma Berenices on a track that will take it across a rich, deep galaxy field, encountering the likes of M98, M99, M100, M88, M91 and M90.

Throughout December, 24P/Schaumasse's integrated magnitude is expected to increase from around mag. +11.5 on 1 December to +10.0 on New Year's Eve. This places it within small-telescope territory and, given clear skies, it's going to be an exciting object to keep tabs on. The comet has an orbital period of 8.252 years, with its next perihelion on 8 January 2026. During this time, it's expected to reach mag. +9.9 and will be located in southern Boötes, the bright star Arcturus (Alpha (α) Boötis), then providing a convenient navigational aid for locating the comet in the early morning sky.


NGC 4449
URSA MAJOR
LEO MINOR
NGC 2903
λ
μ
ε
Sickle
M94
β
CANES VENATICI
γ
ξ
ζ
α
NGC 4214
Algieba
γ
1 Dec
Ellis 6
η
NGC 4631
COMA BERENICES
6 Dec
Regulus
α
δ
Zosma
PGC 30378
γ
11 Dec
LEO
24P/Schaumasse
M105
ρ
Melotte 111
16 Dec
θ
Chertan
M96
β
NGC 4725
21 Dec
NGC 3628
M66
M65
β
M64
M85
Denebola
ι
M100
26 Dec
31 Dec
M88
M86
σ
M53
α
Diadem
M84
M90
M87
ο
ν
NGC 3521
5 Jan
M80
ρ
M49
ε
Vindemiatrix
M61
Zavijava
β
υ
φ
10 Jan

▲ 24P/Schaumasse drops by several deep-sky objects this month

THE PLANETS Our celestial neighbourhood in December

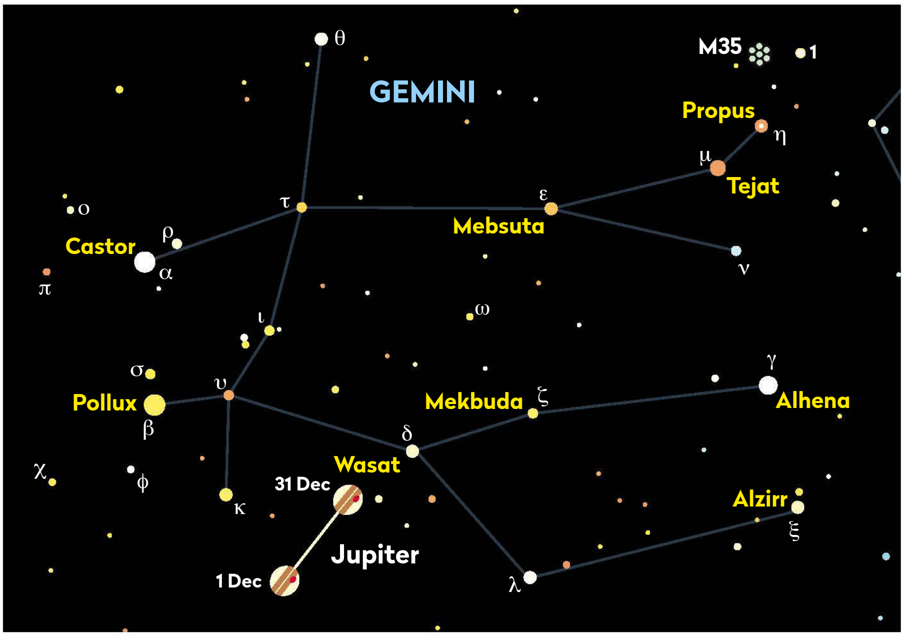
PICK OF THE MONTH

Jupiter

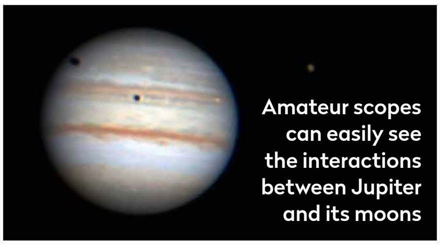
Best time to see: 31 December, 01:05 UT
Altitude: 59°
Location: Gemini
Direction: South
Features: Complex atmosphere, moons
Recommended equipment: 100mm or larger

Jupiter is looking amazing at the moment, a bright mag. –2.4 planet rising to a peak altitude approaching 60° when due south. It's currently located in Gemini, not far from the twin stars Castor and Pollux (Alpha (α) and Beta (β) Geminorum). Reaching such a good height when due south allows Jupiter to lift itself well above Earth's turbulent atmosphere, a welcome situation as it provides for steadier views of the planet.

Jupiter's own atmosphere is very turbulent in its own right, appearing banded when viewed through amateur telescopes. In the southern hemisphere's south equatorial belt (SEB) sits a persistent storm known as the Great Red Spot (GRS). The GRS has been observed for at least 195 years, and over recent years has been shown to be shrinking in longitude span. Getting a view of the GRS is down to luck with timing and the weather, but free software such as WinJUPOS will show the GRS's position for any selected date, allowing you to plan your observing session.


θ
M35
1
GEMINI
Propus
η
μ
Tejat
ε
Mebsuta
ν
o
τ
Castor
ρ
α
π
ω
ι
σ
γ
υ
Pollux
β
Mekbuda
ζ
Alhena
δ
χ
φ
Wasat
κ
31 Dec
Alzirr
ξ
Jupiter
1 Dec
λ

▲ Jupiter is brilliantly placed for observing its moons and dynamic cloud belts



Amateur scopes can easily see the interactions between Jupiter and its moons

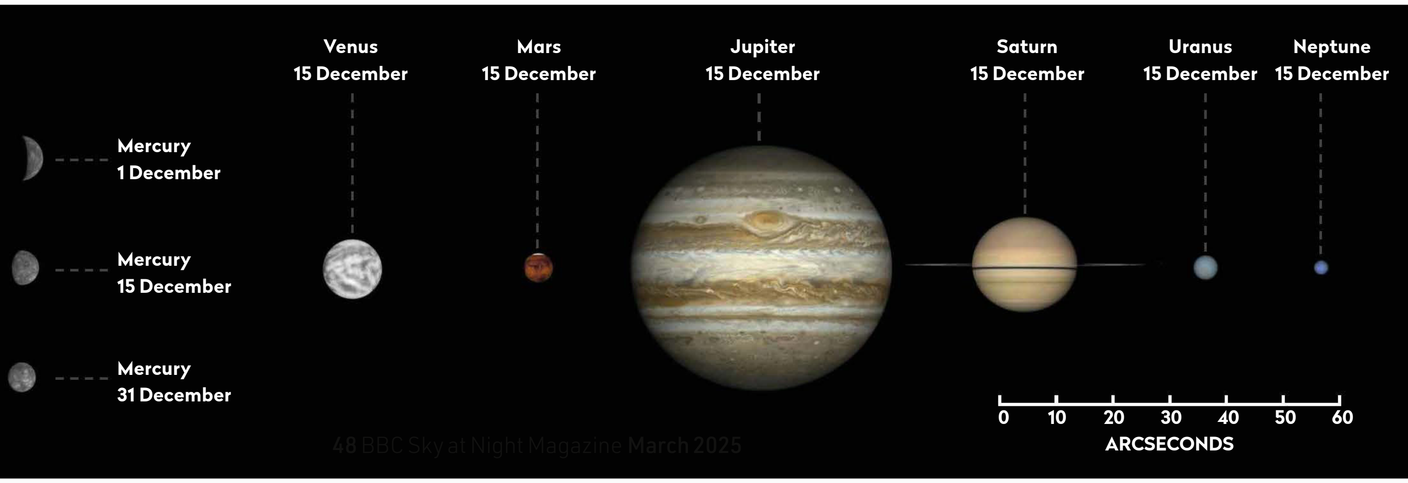
Jupiter's main cloud belts can be seen through a small telescope, along with its four brightest moons: Io, Europa, Ganymede and Callisto. Right now, their apparent interactions with Jupiter's globe are being affected by exciting changes in the planet's orientation. Turn to page 46 for a detailed look at how these moon events will appear this month.

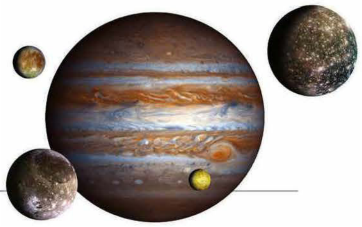
The period between Jupiter's oppositions – when the planet is opposite the Sun in the sky and presented at its best as seen from Earth – is slightly longer than one Earth year. That means that, if the timing is right, it's possible to have a year without Jupiter reaching opposition. 2025 was one such year: the last opposition occurred on 7 December 2024, and the next won't happen until 10 January 2026.

PETE LAWRENCE X 2

The planets in December

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 December
Mars
15 December
Jupiter
15 December
Saturn
15 December
Uranus
15 December
Neptune
15 December
Mercury
1 December
Mercury
15 December
Mercury
31 December
0
10
20
30
40
50
60
ARCSECONDS
48 BBC Sky at Night Magazine March 2025



Mercury

Best time to see: 7 December, 1 hour before sunrise
Altitude: 8.2° (low)
Location: Libra
Direction: Southeast

Morning planet Mercury reaches greatest western elongation on 7 December, rising two hours ahead of the Sun – Mercury rising at 06:09 UT and sunrise occuring at 08:10 UT. On 1 December, Mercury shines at mag. +0.1, brightening to mag. –0.4 by 7 December. The planet remains visible for early risers until around 23 December.

Venus

Like Mercury, Venus is currently a morning planet. However, it's now positioned so close to the Sun in the sky that it's difficult to observe. On a distant part of its orbit, it reaches superior conjunction on 6 January 2026.

Mars

Mars is too close to the Sun to be seen properly this month.

Saturn

Best time to see:
1 December, 19:15 UT
Altitude: 33°
Location: Aquarius
Direction: South

Saturn is well-placed for observation from the UK at the start of December, but its tenure weakens at the end of the month. On 1 December, it reaches a peak altitude of 33° under true darkness, but by the end of the month this occurs under deep twilight. Saturn is currently in Aquarius, really close to the border with Pisces, where it sits just south of the faint but distinctive Circlet asterism in Pisces.

On 1 December, Saturn shines at mag. +0.6, dimming only slightly to +0.7 towards the end of the month. During the first part of December, a telescope view of the planet will barely show the rings at all. From 11 November until 8 December, Saturn's southern pole is tilted towards Earth by just 0.4°, the rings being virtually edge-on to us. Through smaller apertures, it may appear that the planet has no rings at all during this time. On 26 December, Saturn is joined by a 39%-lit waxing crescent Moon, 3.7° to the west northwest at 22:00 UT.

Uranus

Best time to see:
1 December, 23:20 UT
Altitude: 57°
Location: Taurus
Direction: South

Uranus is very well-placed, south of the Pleiades open cluster in Taurus. Shining at mag. +5.6, it's a good time to test the adage that it's possible to see Uranus with the naked eye – although you will need a dark sky to achieve this. The planet's currently visible under true darkness when due south, around 57° up, all month long.

Neptune

Best time to see:
1 December, 19:30 UT
Altitude: 36°
Location: Pisces
Direction: South

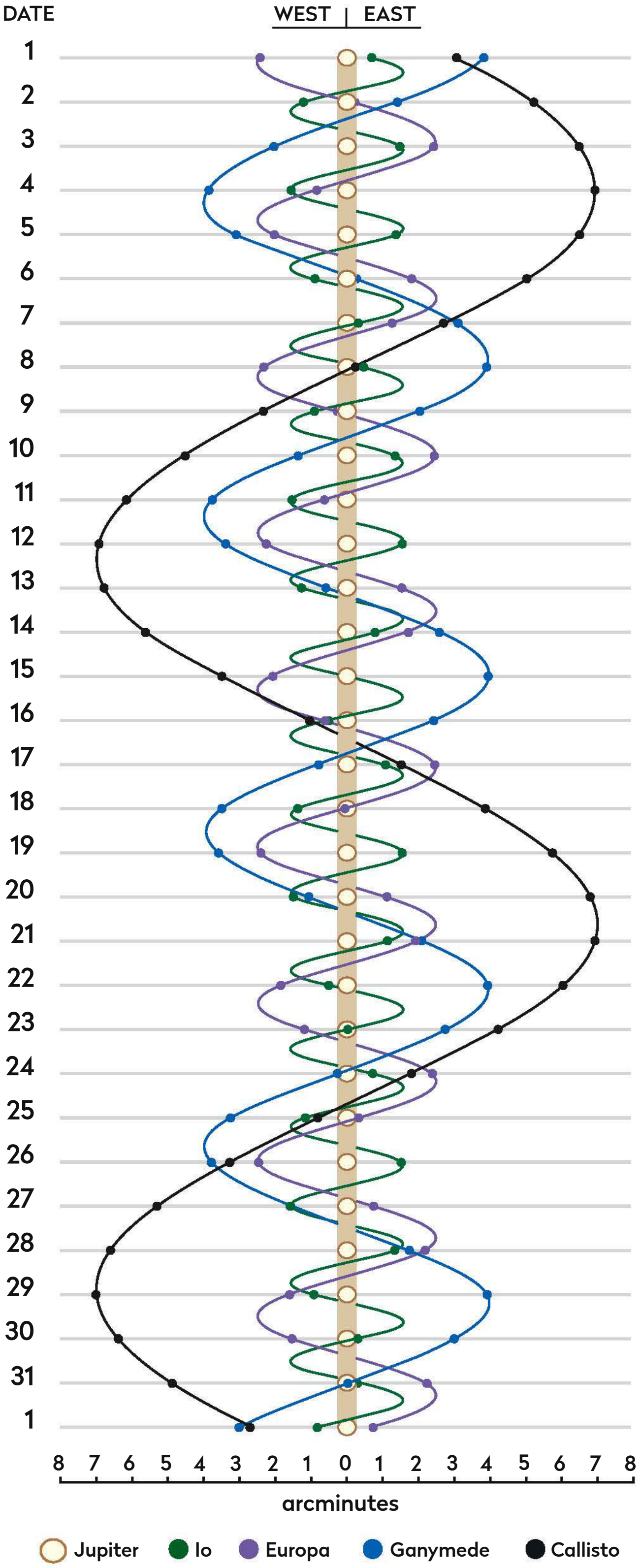
Neptune is located in Pisces, less than 4° from Saturn. Consequently, the best time to view Saturn is also true for Neptune. On 1 December, Neptune achieves an altitude of 36°, due south at 19:30 UT. Shining at magnitude +7.9, you'll need at least binoculars to see the planet.

FREE BONUS CONTENT

Print planet observing forms
www.skyatnightmagazine .com/bonus-content

JUPITER'S MOONS: DECEMBER

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – DECEMBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

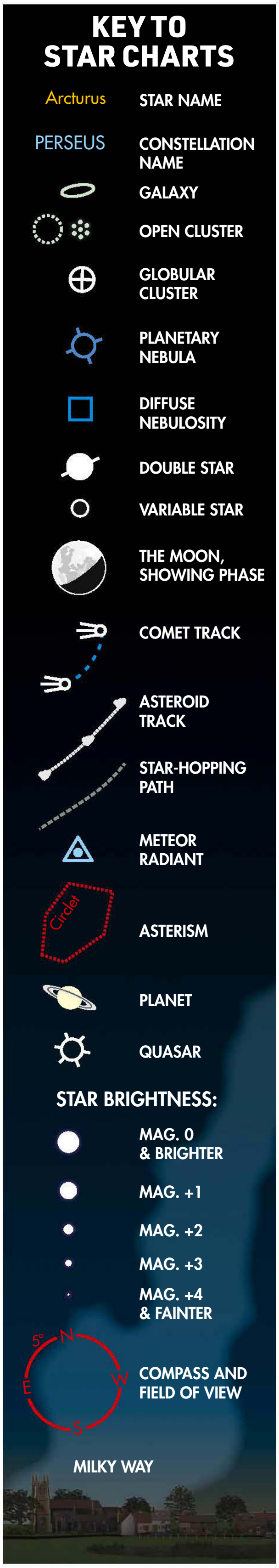

Arcturus
STAR NAME
PERSEUS
CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON, SHOWING PHASE
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet
ASTERISM
PLANET
QUASAR
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER
5°
N
E
W
S
COMPASS AND FIELD OF VIEW
MILKY WAY

CHART: PETE LAWRENCE

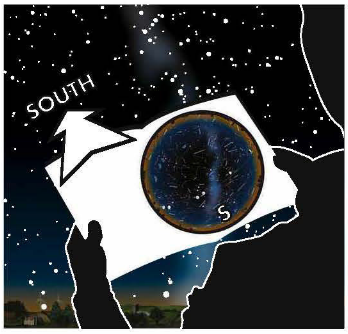
When to use this chart

1 December at 00:00 UT
15 December at 23:00 UT
31 December at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in December*

Date	Sunrise	Sunset
1 Dec 2025	08:03 UT	15:54 UT
11 Dec 2025	08:15 UT	15:50 UT
21 Dec 2025	08:23 UT	15:52 UT
31 Dec 2025	08:26 UT	16:00 UT

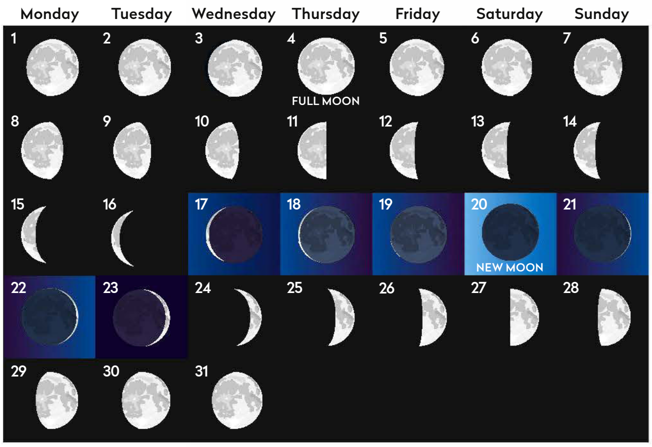
Moonrise in December*

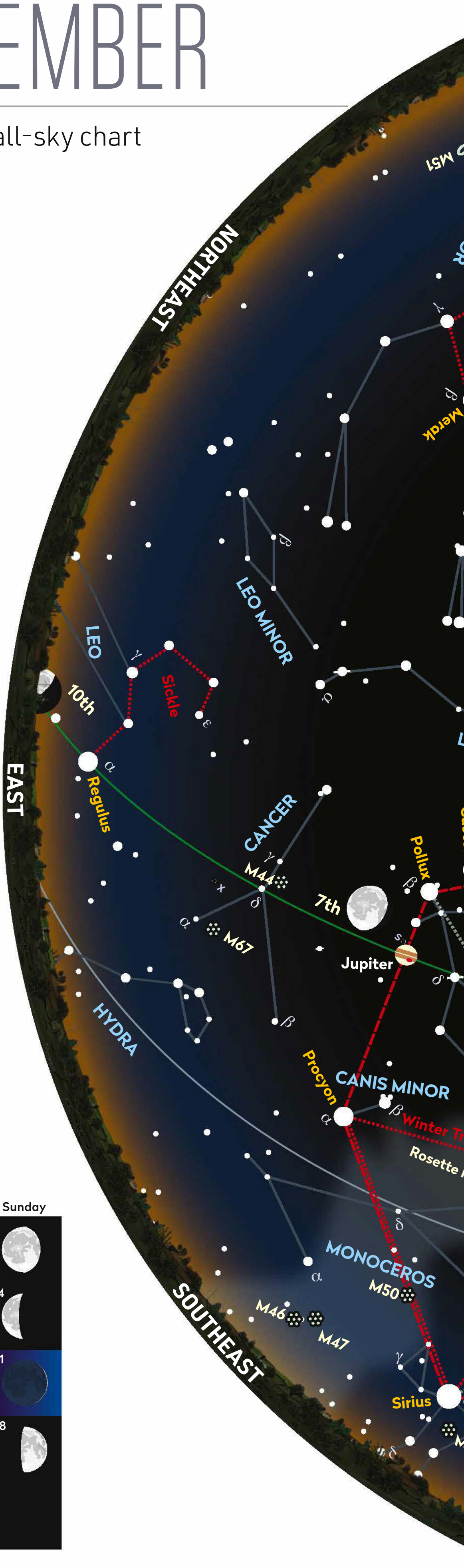
Moonrise times

1 Dec 2025, 13:41 UT
5 Dec 2025, 15:38 UT
9 Dec 2025, 21:20 UT
13 Dec 2025, 01:16 UT
17 Dec 2025, 06:15 UT
21 Dec 2025, 10:08 UT
25 Dec 2025, 11:18 UT
29 Dec 2025, 11:59 UT

*Times correct for the centre of the UK

Lunar phases in December


Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
1
2
3
4
FULL MOON
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
NEW MOON
21
22
23
24
25
26
27
28
29
30
31

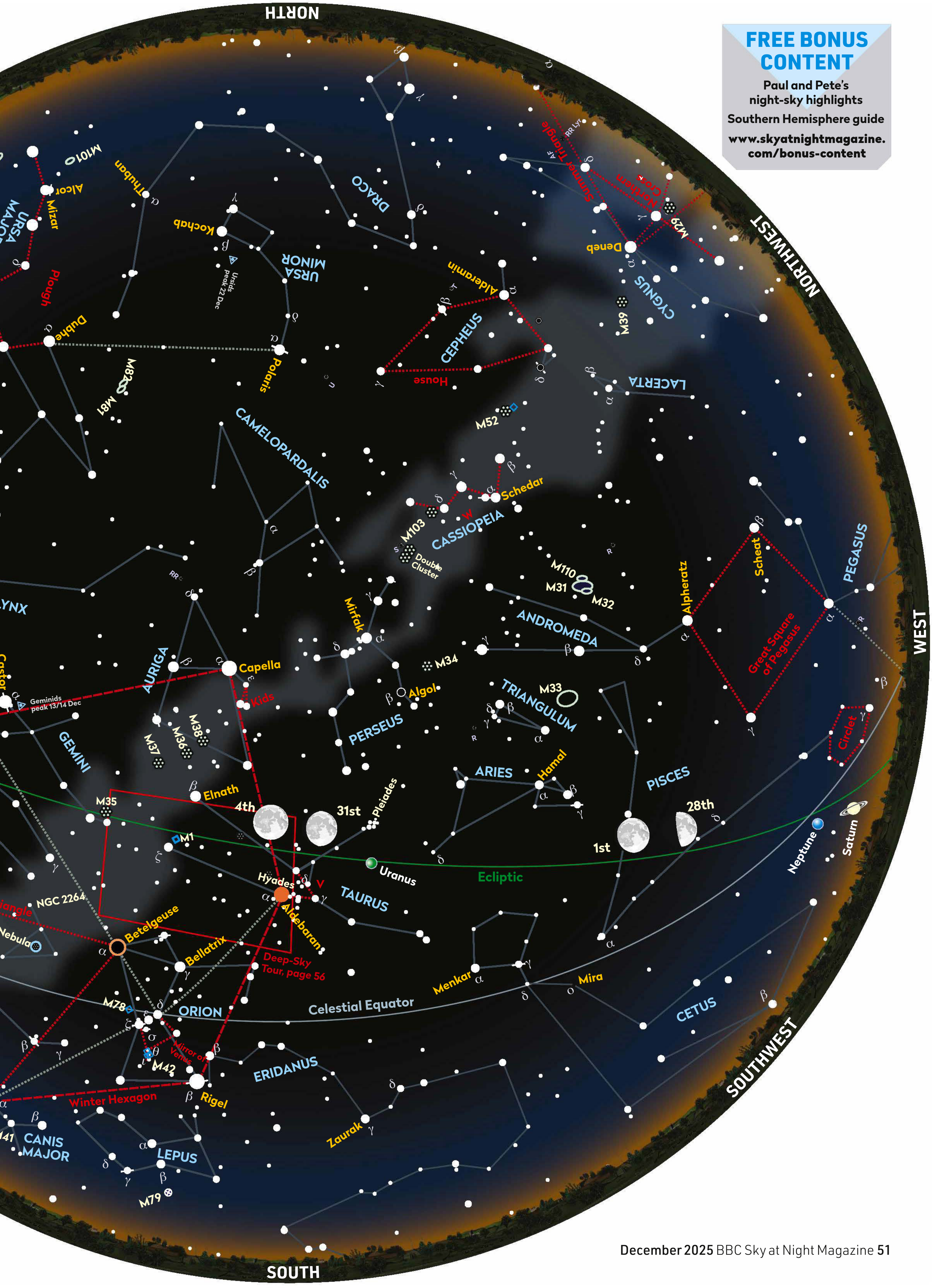

NORTHEAST
EAST
SOUTHEAST
M51
Merak
LEO
LEO MINOR
10th
Sickle
Regulus
CANCER
M44
M67
7th
Pollux
Jupiter
HYDRA
Procyon
CANIS MINOR
Rosette
MONOCEROS
M50
M46
M47
Sirius

FREE BONUS CONTENT

Paul and Pete's night-sky highlights

Southern Hemisphere guide

www.skyatnightmagazine.com/bonus-content

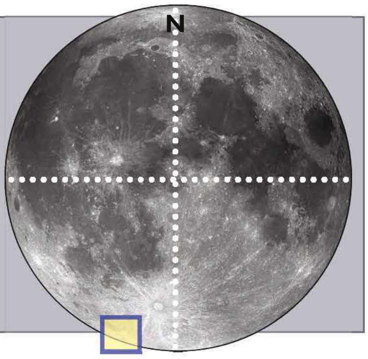

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
M101
Alcor
Mizar
URSA MAJOR
Plough
Thuban
Kochab
Ursids peak 22 Dec
URSA MINOR
DRACO
Dubhe
Polaris
M82
M81
CAMELOPARDALIS
Alderamin
CEPHEUS
House
Summer Triangle
RR Lyr
Northern Cross
M29
Deneb
CYGNUS
M39
LACERTA
M52
Schedar
W
CASSIOPEIA
M103
Double Cluster
M110
M31
M32
ANDROMEDA
Alpheratz
Scheat
PEGASUS
Great Square of Pegasus
Circlet
LYNX
RR
Mirfak
Capella
Kids
AURIGA
Castor
Geminids peak 13/14 Dec
GEMINI
M37
M36
M38
M34
Algol
PERSEUS
TRIANGULUM
M33
ARIES
Hamal
PISCES
M35
Elnath
4th
31st
Pleiades
1st
28th
Neptune
Saturn
M1
Uranus
Ecliptic
Hyades
V
TAURUS
Aldebaran
NGC 2264
Betelgeuse
Bellatrix
Deep-Sky Tour, page 56
Menkar
Mira
CETUS
M78
ORION
Celestial Equator
Mirror of Venus
M42
Rigel
ERIDANUS
Winter Hexagon
Zaurak
CANIS MAJOR
M41
LEPUS
M79

MOONWATCH

December's top lunar feature to observe

Scheiner

Type: Crater
Size: 111km
Longitude/latitude: 27.8° W, 60.4° S
Age: Around older than 3.9 billion years
Best time to see: Two days after first quarter (29 December) or one day after last quarter (13–14 December)
Minimum equipment: 10x binoculars



Crater **Scheiner** has an impressive diameter of 111km. However, it's a feature located in the far south of the Moon, so from Earth it often appears heavily foreshortened, taking on an elliptical shape. We say 'often', because at 60.4° south, Scheiner is in an interesting part of the Moon that is strongly affected by libration. 'Libration' is the term that describes how the Moon appears to rock and roll as seen from Earth. The effect is caused by the tilt and ellipticity of the Moon's orbit and allows us to see a total of 59 per cent of the Moon's globe over time.

> **"Scheiner is in an interesting part of the Moon that's strongly affected by libration"**

Scheiner is easy to locate, as it sits just to the west of one of the largest and most distinctive craters on the Earth-facing side of the Moon: 225km **Clavius**. This too is affected by libration, but being such a large feature in its own right, seems to wear the effects better than Scheiner. We'll get a good opportunity to spot the variation in appearance caused by libration in the first half of December.

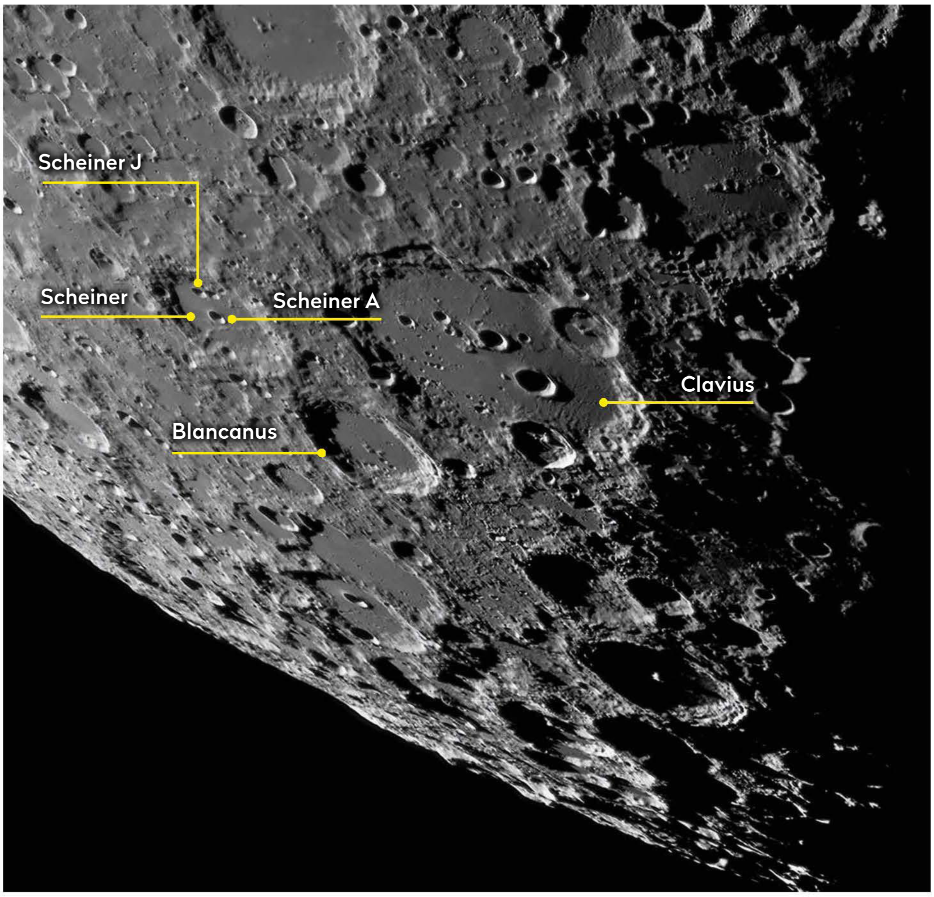
On 1 December, Scheiner and Clavius are well presented, showing minimal libration effects because the southern edge of the Moon is tilted towards us. As the month progresses, Scheiner initially appears to hold its own, but gradually succumbs as the northern regions of the Moon begin to tilt towards us. This causes Scheiner to appear to move closer to the lunar limb and, as a result, look more foreshortened. The effect will be particularly prominent just before the evening terminator reaches Scheiner on 14 December.

Scheiner itself is a fairly well-preserved feature, although its battered rim shows that it's an ancient crater. The rim is complete, save for a gap in the north. A small cluster of craterlets sits at the lower side of this gap on Scheiner's floor, two of almost identical size, 11.5km across, but only the west one has been given a label: **Scheiner J**. Scheiner's floor is relatively flat, with an east–west ridge appearing to run across the floor just to the south of 12.1km **Scheiner A**. Like the pair mentioned earlier, Scheiner A is perfectly formed, with a smooth, slightly elevated rim that curves down to a minimum height 2km below the edge – though it never quite forms a flat floor.

The east–west ridge is fairly gentle, rising to a peak height of 200–250 metres. Consequently, it's a feature best seen when the lighting is low in Scheiner's sky – in other words, when the terminator is nearby. Towards the southern rim of the main crater, the floor becomes bumpy and ill-defined, slowly climbing to a height of just over 4km above the main floor.

Heading south-southeast from Scheiner takes you to **Blancanus**. Around 3.9 billion years old, Blancanus measures 106km across and is well-defined and terraced. Its rim towers nearly 5km above what is mostly a flat floor, with a few scattered craterlets to the south under what appears to be a low-rise central mountain complex. Of similar size to Scheiner, Blancanus suffers the same apparent change in appearance due to libration.

▼ Scheiner, west of Clavius in the southern highlands, appears to shift shape as the Moon tilts and rolls



PETE LAWRENCE X 3

COMETS AND ASTEROIDS

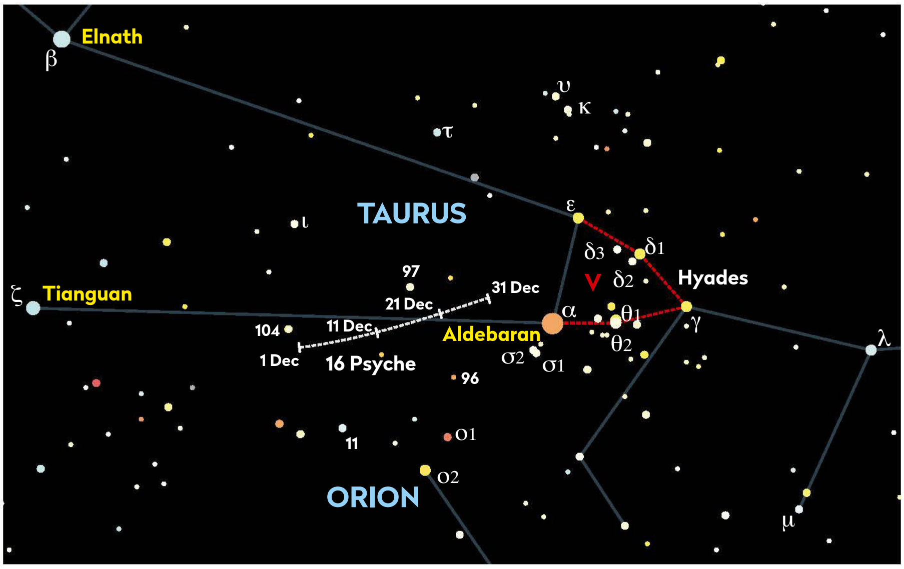
Spot 16 Psyche gliding towards Aldebaran

Asteroid 16 Psyche reaches opposition on 8 December in an easy-to-navigate part of the sky, just east of the Hyades open cluster and the bright star Aldebaran (Alpha (α) Tauri). Its path over the course of the month is fairly short too, so once identified, it will be easy to keep track of.

Psyche starts December 7.5° east and a fraction north of Aldebaran. At 00:00 UT on 1 December, this positions it 0.5° south and slightly west of the mag. +4.9 star 104 Tauri. Psyche's monthly track has it moving west against the background stars, curving very gently south in the first half of December, then slightly north again in the second half of the month. At 00:00 UT on 31 December, the asteroid sits 1.8° northeast of Aldebaran.

Psyche's magnitude stays relatively steady, brightening from mag. +9.8 on 1 December to +9.6 at opposition on 8 December, then dimming to +10.2 by the end of the month. This places it within small-telescope range, and its high altitude in UK skies makes it an excellent target for beginners.

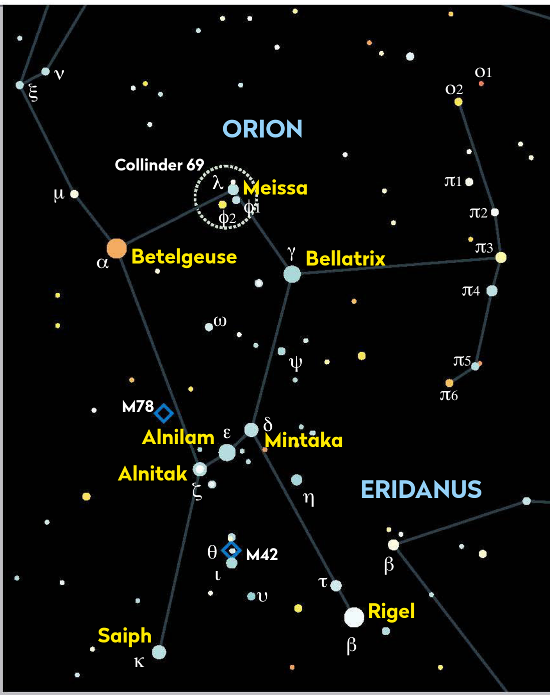
Psyche is thought to be the iron core of a failed planet. Shaped like a potato and measuring roughly 279km by 323km by 189km, its iron composition means it's unusually massive for an asteroid – around 2.3 × 10^{19}kg. It orbits the Sun at an average distance of 2.9 AU. It takes just under five years to complete each orbit, rotating once every 4.2 hours.



▲ **Psyche's westerly path this month: the minor planet is a great one for beginners to track**

STAR OF THE MONTH

Meet Orion's hothead – Meissa, a blazing O-type giant



▲ **Meissa (Lambda (λ) Orionis) is easy to identify as it marks Orion's head**

Most people can recognise the iconic shape of Orion, formed from seven bright stars, representing the body of a hunter. Once you've picked it out, it's easy to locate Orion's 'head', marked by the star Meissa (Lambda (λ) Orionis).

This mag. +3.4 star forms the northern point of a small right-angled triangle with mag. +4.4 Phi^1 (φ^1) and +4.1 Phi^2 (φ^2) Orionis. The name Meissa comes from the Arabic 'Al-Maisan', meaning 'the Shining One'. A lovely description, but one intended for another star: Alhena (Gamma (γ) Geminorum). The name was mistakenly transferred to Lambda Orionis, an error that persists to the present day.

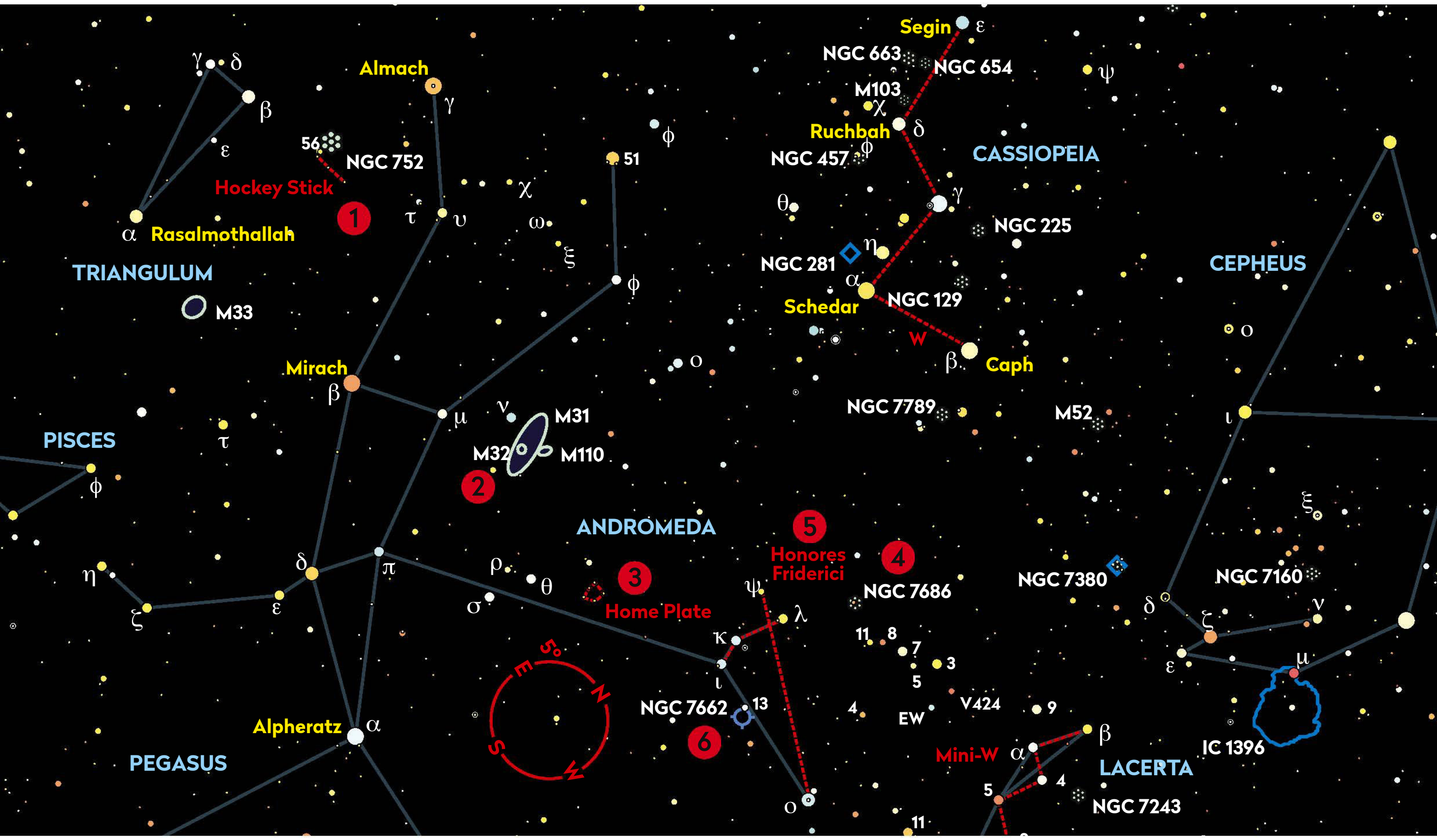
Meissa has a spectral class of O8 III, the O8 indicating that it's a hot blue-white star, and the III indicating that it's a giant. It's estimated to be around 34 times more massive and physically 10 times larger than our Sun. It's also a double star: its secondary shines at magnitude +5.6 and sits 4.4 arcseconds away. The secondary has a spectral class of B0 V, indicating it's a B-type main-sequence star.

Located around 1,300 lightyears from the Sun, Meissa is the brightest member of the Lambda Orionis Cluster, an open star cluster also known as Collinder 69. This is a young object, just five million years old, and contains a large number of low-mass stars.

The whole region around Orion's head is filled with nebulosity, a molecular cloud and H II region catalogued as Sharpless 2-264. Long-exposure images reveal a pink colour and a shape that have led to it being dubbed the Angelfish Nebula. It's quite a large feature, approaching 7° in apparent diameter. A widefield, long exposure of Orion will show Sharpless 2-264 sitting just north of the large ring of nebulosity known as Barnard's Loop. Together they give Orion a surprising alter ego: not a hunter but a cosmic snowman.

BINOCULAR TOUR With Steve Tonkin

Game on! Find a hockey stick, a home plate and end with a blue knockout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1 The Hockey Stick

10x50 Use the chart to identify NGC 752. Near its southwest edge you'll see the components of the easy double star 56 Andromedae, shining at mag. +5.6 and +5.9. Extending northwest is a 1.6° chain of sixth and seventh-magnitude stars that form a hockey stick shape; 56 Andromedae is the toe end and NGC 752 is the oversized ball. This is a line-of-sight association: NGC 752 is four times farther away than 56 Andromedae. ☐ **SEEN IT**

2. The Andromeda Galaxy

10x50 If you can't see this galaxy with your unaided eye, start with mag. +2.0 Mirach (Beta (β) Andromedae) at one side of the field of view and mag. +3.9 Mu (μ) Andromedae at the other. Pan across so that Mu Andromedae is where Mirach was, and the elliptical shape of M31, the Andromeda Galaxy, will appear where Mu was. Can you identify the two companion galaxies, M32 and M110, which look like defocused stars? ☐ **SEEN IT**

3. The Home Plate

10x50 Here's another sporting asterism. Starting at mag. +4.6 Theta (θ) Andromedae, pan 2.5° (about half a 10x50 field of view) northwest. Here you'll find an irregular pentagon of yellowish seventh-magnitude stars covering an area of about 0.5° x 0.75°. It looks like the home plate that a baseball batter must touch to complete a run. Can you identify which three of the corners are multiple stars? ☐ **SEEN IT**

4. NGC 7686

10x50 Begin at mag. +4.1 Kappa (κ) and mag. +3.9 Lambda (λ) Andromedae. Imagine a line connecting the two, then extend that same distance northwards. You'll arrive at an obvious pair of stars, 5 arcminutes apart. The brighter of the pair, at mag. +6.2, sits at the centre of a 16-arcminute-wide glow: the open cluster NGC 7686. At a distance of 5,000 lightyears, that span translates to around 23 lightyears across. ☐ **SEEN IT**

5. Honores Friderici

10x50 In 1787, the year after Frederick the Great's death, German astronomer Johann Bode created the now-defunct constellation Honores Friderici (Frederick's Regalia) to honour him, representing a sword and quill, wreathed in laurel. Binoculars bring out the varied colours of the stars, ranging from the blue-white of Omicron (ο) Andromedae to the orange-red of 8 Andromedae. ☐ **SEEN IT**

6. NGC 7662

15x70 Switch to larger binoculars for this planetary nebula, as they'll reveal the colour that will help you identify it. From mag. +4.3 Iota (ι) Andromedae, scan 2° west to mag. +5.7 13 Andromedae. NGC 7662 lies 0.5° to the south-southwest, appearing as an eighth-magnitude star with a blue-green hue that sets it apart from the surrounding white stars. Defocus slightly to bring out the colour. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

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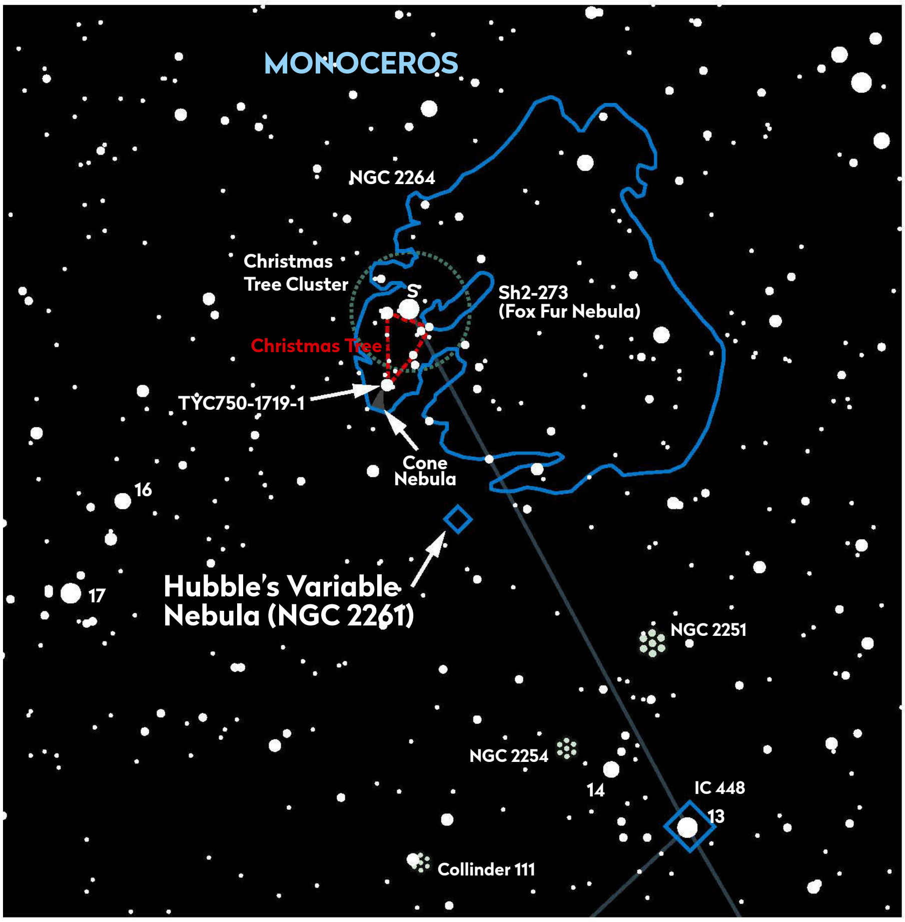
THE SKY GUIDE CHALLENGE

Record the dramatic flickering in Hubble's Variable Nebula



▲ **Hubble's Variable Nebula (NGC 2261) exhibits a fascinating phenomenon, appearing to change shape and brightness when vast, moving dust clouds cast shadows onto the nebula**

In the world of astronomy, we cherish things that change in appearance, because those changes reveal information. Plotting the light curve of a variable star, for example, tells us a great deal about the star and what causes its variability. Shifts in planetary atmospheres or even on the surface of the Sun offer insights into how these bodies work. The movement of light across the lunar surface reveals how the terrain and its features are 'constructed'.

But when it comes to changing appearances, the deep sky doesn't immediately spring to mind. Yet some deep-sky objects do vary. Obvious examples include galaxies that host supernovae outbursts. But there's an amazing object – well within the range of amateur equipment – that changes for a different reason.

Hubble's Variable Nebula (NGC 2261) appears to fluctuate in brightness over time due to shadows. It's illuminated by a young binary star system, R Monocerotis, and dark dust clouds orbiting the star system cast vast shadows across the nebula. From Earth, we see this as changes in apparent brightness.

> ***"The changes are typically visible over months or years"***

Located in Monoceros, 1.2° south and 0.4° west of the Christmas Tree Cluster, this comet-shaped nebula typically shines with an integrated magnitude of +9.0, making it suitable for both small and large telescopes. The changes in brightness aren't particularly rapid – they're typically visible over months or years – which opens up interesting opportunities.

For one, poor weather isn't a major obstacle; you'll hopefully get several clear, moonless nights to make your record. It's also ideal for a long-term photographic sequence – just remember to schedule in repeat observations.

Hubble's Variable Nebula measures two arcminutes across and has a roughly triangular shape. It can be captured using smart scopes. For the best results, we'd recommend a bit of magnification to reveal the nebula's shape. Ideally, stick to the same kit and the same imaging workflow each time. Be especially careful not to overexpose the nebula's brightest region, near R Monocerotis. Record the date and time of each image and keep them safe. Finally, align the stars from each frame and combine them into an animated sequence to show just how variable Hubble's Variable Nebula can be.

The strange, fan-shaped nebula is lit by the star R Monocerotis

DEEP-SKY TOUR

Hop from Orion's head to this month's targets, from beginner favourites to more elusive gems

1. Collinder 69

Orion's head is marked by the star Meissa (Lambda (λ) Orionis). With the naked eye, Meissa is joined by Phi^1 (ϕ^1) and Phi^2 (ϕ^2) Orionis to form a right-angled triangle around 45 arcminutes wide. A small scope will show many more stars intertwined with the main group, with a distinctive line of three seventh-magnitude stars between Meissa and Phi^1. These are all part of the Collinder 69 cluster, also known as the Lambda Orionis Cluster. Larger instruments and OIII or H-beta filters reveal faint nebulosity, identified as Sharpless 2-264, particularly around the brighter stars. ☐ **SEEN IT**

2. NGC 2169

NGC 2169 marks the southern right angle in a right-angled triangle formed with mag. +4.4 Nu (ν) and +4.4 Xi (ξ) Orionis. Measuring 7 arcminutes across and with a magnitude of +5.9, it's a lovely open cluster – with a secret. Its brightest members form the outline of the number '37', earning its nickname, the 37 Cluster. It's a real treat and well worth tracking down. The '37' shape can look odd through different telescope types, so be prepared to apply a bit of artistic licence. Somewhat less glamorously, the pattern can be interpreted as the outline of a shopping trolley! ☐ **SEEN IT**

3. Collinder 65

A wide-open cluster such as Collinder 69 deserves a low power to do it justice. However, a *very* low power is required for our next cluster, another entry in the Collinder Catalogue. Located 7.8° north-northwest of Meissa, Collinder 65 measures 220 arcminutes across and is visible to the naked eye. It's a very scattered object that will fill the field of view of an average widefield eyepiece, with around 40 stars between mag. +5 and +10 visible through a 100mm scope. Although not a dynamic, highly concentrated cluster, it does contain lovely double stars, including Σ730 (Struve 730), Σ697, S478, OΣ 107 (Otto Struve 107) and OΣ 108. ☐ **SEEN IT**

GÜNTER KERSCHHUBER, CCDGUIDE.COM | CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.

EQTOUR V1.17
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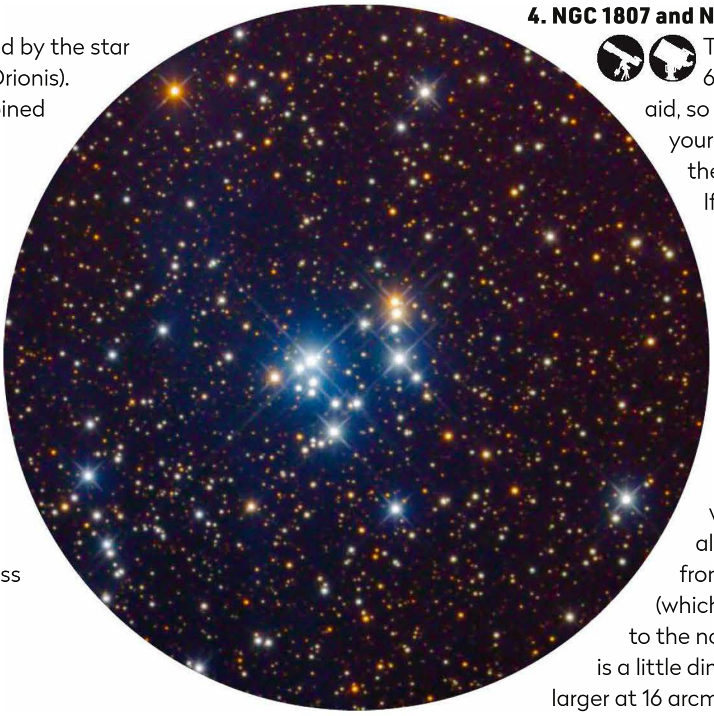

▲ **Shopping trolley or '37' – what do you see? Track down NGC 2169 and decide for yourself**

FREE BONUS CONTENT

Print this chart and take the Go-To tour
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4. NGC 1807 and NGC 1817

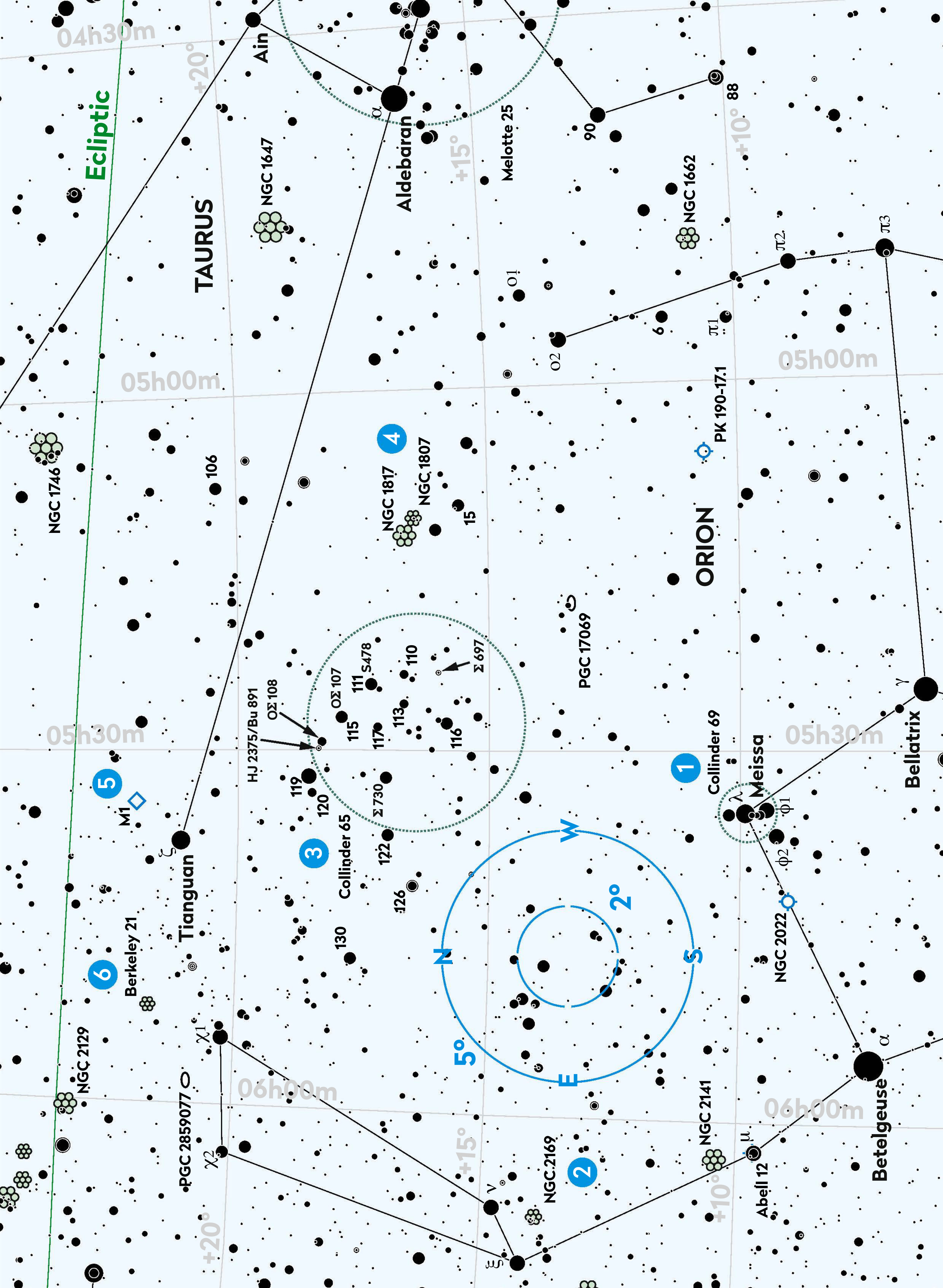
The diffuse nature of Collinder 65 makes it a poor navigational aid, so to find our next targets, retrace your steps back to Meissa. From there, head 8.8° to the northwest. If you can find mag. +4.8 15 Orionis, the close clusters NGC 1807 and NGC 1817 sit just under one degree north and slightly east of this star. NGC 1807 is a seventh-magnitude object measuring 5 arcminutes across. It's an interesting collection that has attracted controversy as to whether it's actually a cluster at all, or more likely a few stragglers from neighbouring NGC 1817 (which is a true cluster). Located 0.4° to the northeast of NGC 1807, NGC 1817 is a little dimmer at mag. +7.7, but notably larger at 16 arcminutes across. A small scope shows around 30 stars in NGC 1817. ☐ **SEEN IT**

5. M1

Messier 1, the Crab Nebula, is relatively easy to locate, lying 1.1° northwest of Tianguan (Zeta (ζ) Tauri). It's the first entry in Messier's Catalogue and represents the remnants of a star observed exploding in AD 1054. A 150mm scope shows it as a ninth-magnitude elongated haze, 5 x 3 arcminutes across. Its oval shape appears mottled and, with a little imagination, you might make out a rough 'S' shape formed by the brighter regions. M1 generally appears uneven in brightness, with the northwest half brighter than the rest. Some think the nebula resembles a faint comet with a short tail – fitting for the first entry in a catalogue Messier created specifically to list objects that could be mistaken for comets. ☐ **SEEN IT**

6. Berkeley 21

Our final target is the open cluster Berkeley 21. Objects in the Berkeley Open Cluster Catalogue tend to be faint, and Berkeley 21 is no exception. This makes it our challenge object for the month. It's located 3.5° east of M1, sitting 1.9° north-northwest of mag. +4.4 Chi^1 (χ^1) Orionis. It's listed as 11th magnitude, but this is an integrated value. The brightest stars are around 14th magnitude, so larger apertures or photographic setups are recommended. A wobbly line of four stars of mag. +11.5, +10.0, +11.3 and +11.5 leads the way towards the faint mistiness formed by the stars in this rich cluster. The cluster is around 4 arcminutes across and you'll need a good, dark sky to stand any chance of detecting it. ☐ **SEEN IT**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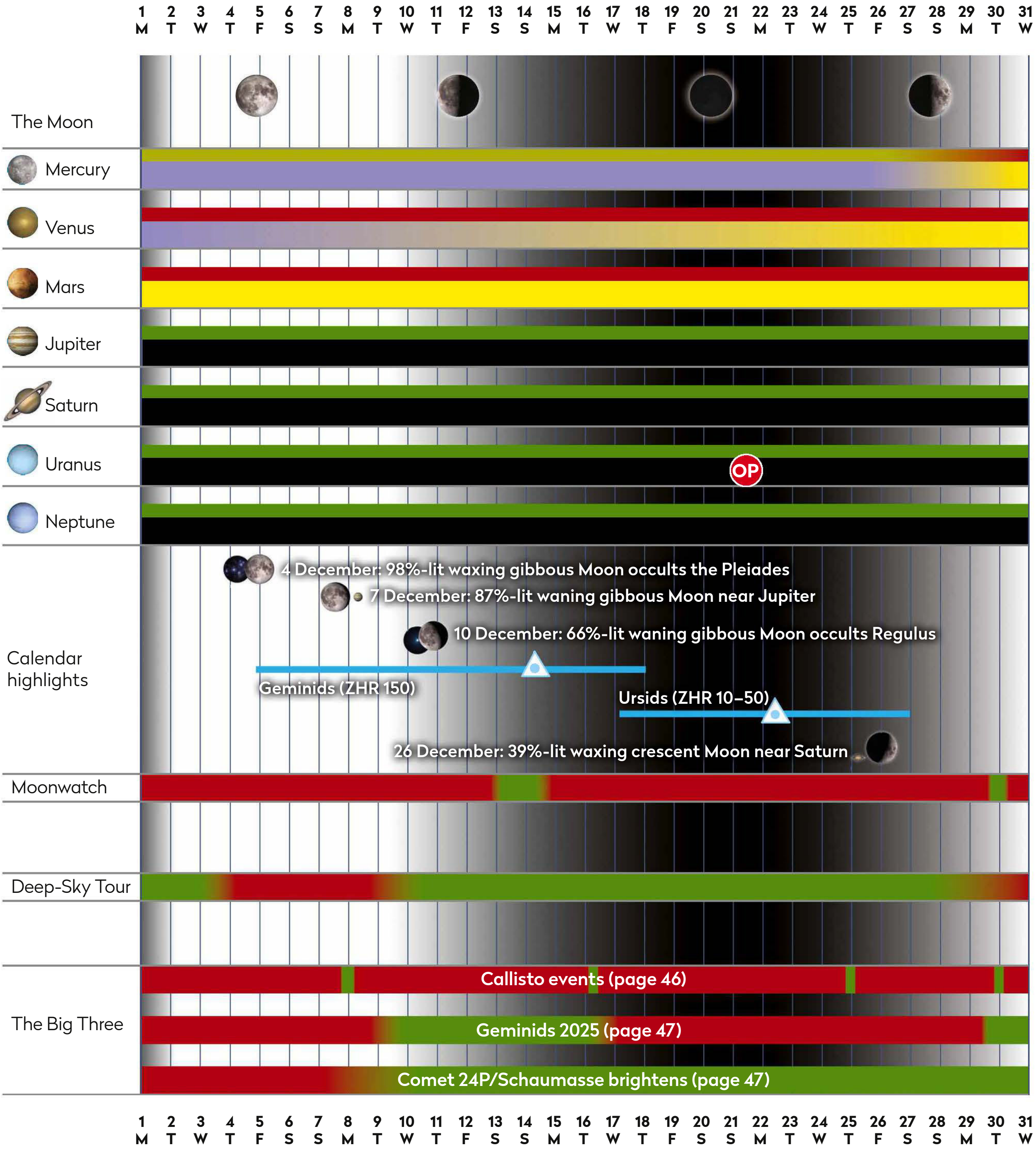
AT A GLANCE

How the Sky Guide events will appear in December



KEY

Observability 🟩 Optimal 🟨 Fair 🟥 Poor

Best viewed Morning twilight · Daytime · Evening twilight · Deep twilight · Night

Sky brightness during lunar phases Dark (first quarter) · Light (full Moon) · Dark (last quarter) · Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

△ Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

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10 Christmas crackers *for your new telescope*

So Santa brought you a telescope – what now? **Stuart Atkinson** sprinkles some cosmic sparkle, with 10 sights to see over one fabulous festive night – from glorious galaxies and planets to glittering star clusters

Light up Christmas night with the gorgeous Orion Nebula – number 9 on our 10-stop festive tour

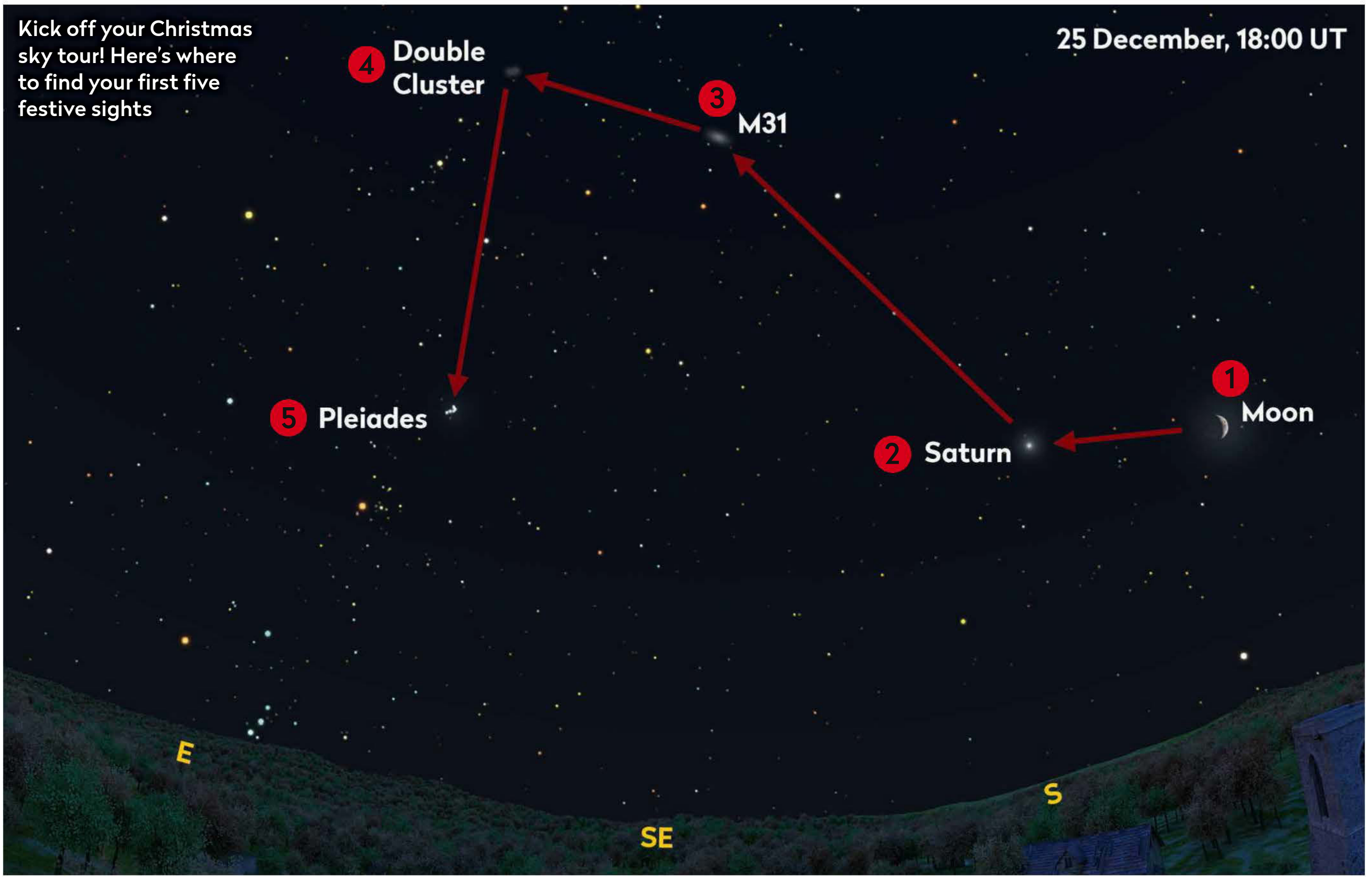
You may have bought this December issue of *BBC Sky at Night Magazine* because you've been given – or you've treated yourself to – a new telescope for Christmas. And you may be wondering what to do with it now you've got it. If so, we're here to help!

Every stargazer starts here. Even those with Dobsonian telescopes the size of a WW2 battleship cannon or the latest computer-controlled astrophotography rigs once stood where you are now and asked: "So… what do I do next?".

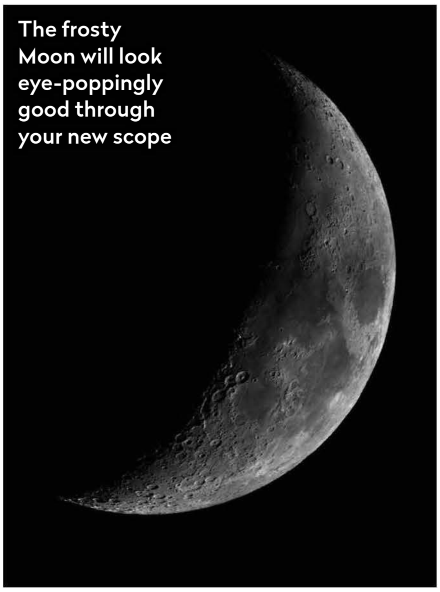
If you haven't got a clue what to look at through your new telescope as darkness falls on Christmas Day, this feature is for you. Think of it as a cosmic selection box of fascinating festive treats, sights that will make you say "Wow!" and call your family away from the TV – as they munch their way through another box of chocolates – to come outside and share the view.

This tour is split into two sessions, so you can enjoy the first half early in the evening (from around 6pm), then head inside to warm up before going back outside at around 9pm to see the rest. And you can do it any night over Christmas week; just be aware the Moon will change position and get brighter.

Ready? Then let's get started. We'll begin with the easiest targets, the sights you'll see if you look to the south after the sky darkens on Christmas Day…


Kick off your Christmas sky tour! Here's where to find your first five festive sights

25 December, 18:00 UT


The frosty Moon will look eye-poppingly good through your new scope

PART ONE
Start at around 6pm…

1. The Moon

The Moon is the easiest celestial object to find in the night sky because it's so bright. You've seen it countless times, but tonight your new telescope will reveal it as never before.

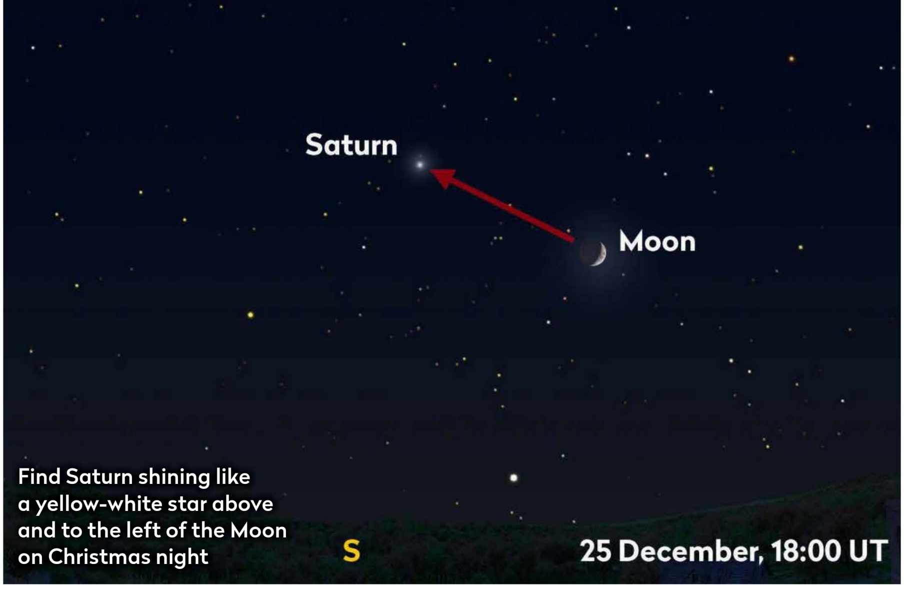
On Christmas night, it will be a beautiful silvery crescent to the naked eye, shining brightly above the southern horizon. But once you've found it with your telescope, and centred it in your lowest-magnification eyepiece (denoted by a large number with 'mm' after it), it will be transformed into a spectacular alien world. You'll see its surface has flat, dark areas and brighter, more rugged regions. The dark areas are the 'seas', but they're seas of frozen ancient lava, not water.

The brighter areas are the battered and beaten highlands, covered with craters and mountain ranges. Using a higher-magnification eyepiece (a smaller number with 'mm' after it), you'll see amazing detail, with craters overlapping so thickly they're impossible to count.

2. Saturn, the Ringed Planet

You've probably been looking forward to this for years – in fact, Saturn might even be why you bought your new telescope. On Christmas night, the famously ringed planet will be easy to find, close to the Moon, shining like a yellow-white star to ▶

JOHANNES SCHEDLER, CCDGUIDE.COM | GETTY | CHART BY PETE LAWRENCE | OLIVER SCHNEIDER, CCDGUIDE.COM



Find Saturn shining like a yellow-white star above and to the left of the Moon on Christmas night

▶ its upper left. It might take a few tries to find it with your scope, but don't worry – it will be worth the frustration! Start with your lowest-power eyepiece again.

Once you've found the planet, use higher magnification until the famous rings are clearly visible. Your first view of the rings might be a little disappointing – right now, they aren't open very wide. Their angle changes slowly over time as Saturn moves around the Sun, so they appear to open and close across the years. Even so, you *will* see them and even at this angle they're still a stunning sight.

Visit the Andromeda Galaxy – at 2.5 million lightyears away, it's our nearest neighbour

3. M31, the Andromeda Galaxy

After Saturn, turn your gaze to the upper left of it – specifically, to the left of a large square of stars known, fittingly, as the Great Square of Pegasus. If your sky isn't spoiled by light pollution, with the naked eye you may spot what looks like a small, misty smudge. This is M31, the Andromeda Galaxy.

Slowly and carefully move your telescope over and up towards it. In your lowest-power eyepiece, it will appear as a large, misty grey-white oval. This is actually the best view you'll get, because increasing the magnification will only dim the image. This 'smudge' is a huge spiral galaxy – bigger than our own Milky Way – containing billions of stars. And it's so far away that the light reaching your new telescope tonight set off more than *two million* years ago.

4. The Double Cluster

The Pleiades twinkle like tinsel through the eyepiece

Diamonds in the dark: don't miss the glittering Double Cluster in Perseus

Look directly to the left of M31, halfway between a very distinctive 'W' of stars and a less distinctive upside-down 'Y' of stars. There you'll see another 'smudge' out of the corner of your eye. This is the very famous Double Cluster and, as its name suggests, it's not a lone star cluster but two very close together. Although they're visible to the naked eye, these clusters – which lie almost 7,000 lightyears away from Earth and contain many thousands of stars – will be a truly spectacular sight in your new telescope, looking like two glittering heaps of diamond dust in its lowest-power eyepiece. You'll naturally be tempted to boost the magnification, but resist: if you push it too high, you'll only be able to see a small part of the cluster, not the whole thing.

5. M45, the Pleiades or Seven Sisters

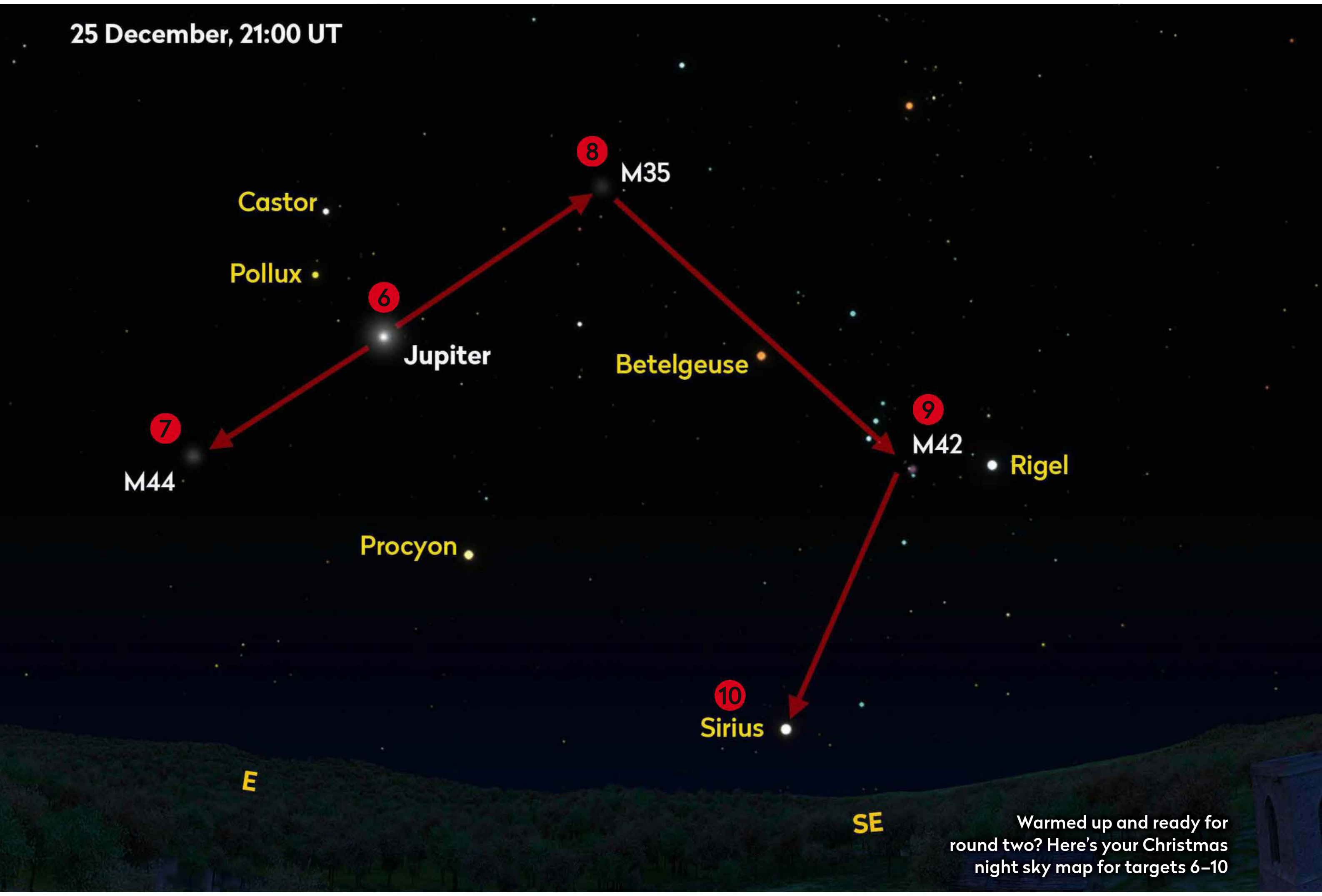
Now look down to the lower right of the Double Cluster. You'll notice a small knot of silvery-blue stars, about the size of your thumbnail held out at arm's length. If you have good eyesight, and your sky isn't impacted too much by light pollution, you might count six or possibly seven stars, arranged in roughly the same shape as the Big Dipper. This is the famous Pleiades, or Seven Sisters, a lovely star cluster 430 lightyears away.

Once it's centred in your telescope's lowest-magnification eyepiece, you'll see a lot more than seven stars twinkling away – you'll see hundreds! In fact, even your widest view may struggle to show the whole cluster. And boosting the magnification will fill your view with thousands of stars, like jewels spilled on black velvet. It really is a magical sight to savour on your first night with your new telescope.

❄❄❄ TIME FOR A BREAK ❄❄❄

Go inside for a well-earned cup of tea. Come back out again in a couple of hours, when the objects in the second half of our tour have had time to rise higher in the sky...

CHARTS BY PETE LAWRENCE | KAZUSHI INAGAKI, GETTY | HAITONG YU, GETTY | VALERIOPARDI, GETTY | ALMAJE, GETTY | ROBIN SCAGELL, GALAXY PICTURE LIBRARY, ALAMY



Warmed up and ready for round two? Here's your Christmas night sky map for targets 6–10

PART TWO
Continue from 9pm...

6. Jupiter

Now that you've warmed up, take a look towards the southeast and you'll see a strikingly bright blue-white 'star' blazing almost halfway up in the sky. This is another planet: mighty Jupiter, the biggest planet in our Solar System. It's so huge, it could swallow up a thousand Earths, with room to spare. Unlike our own rocky planet, Jupiter is a gas giant, an enormous bloated ball of gases and liquids with no solid surface, 630 million km (391 million miles) away!

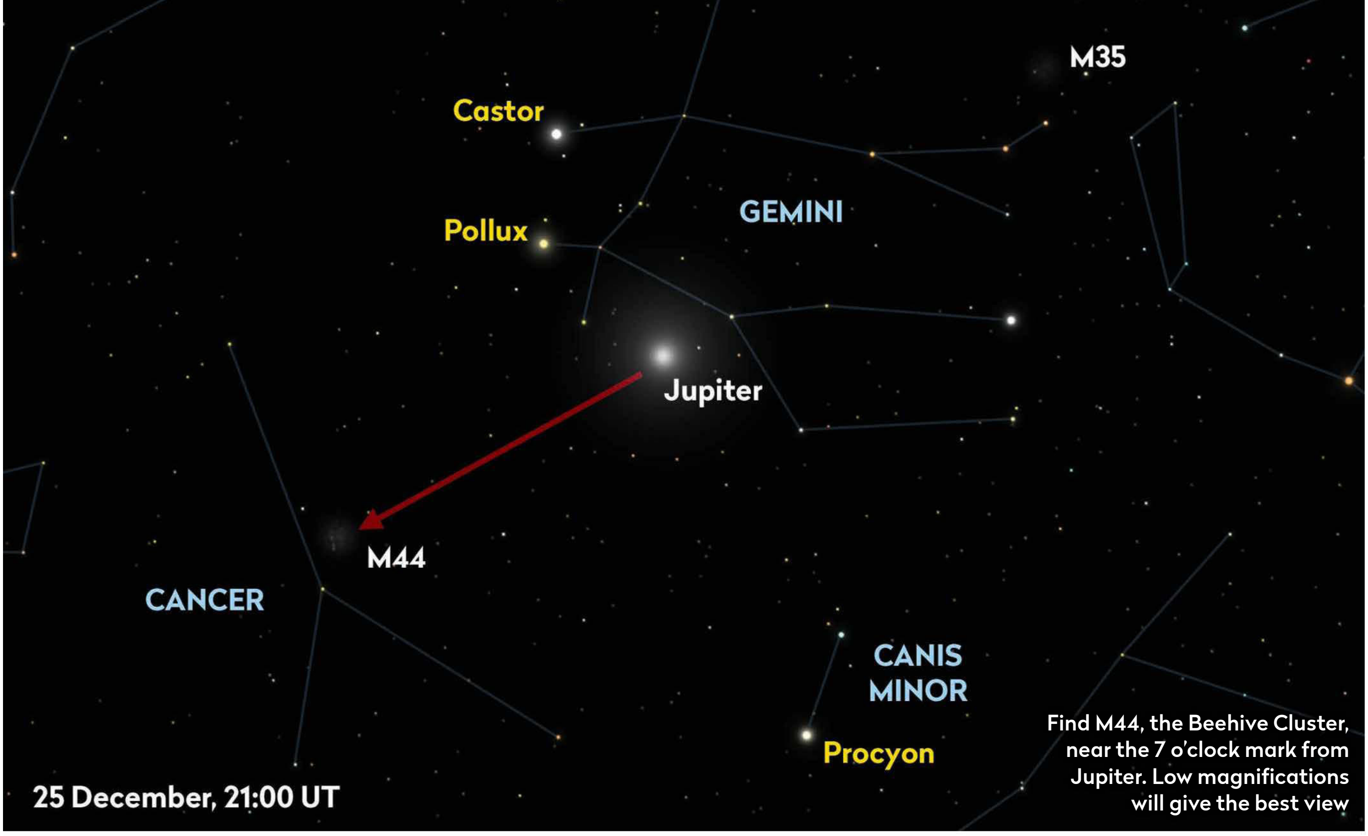
Once you've found it in your telescope's lowest-power eyepiece, push the magnification until you can see the planet's pale, creamy disc is flattened at its poles and that several dark, horizontal bands of cloud cross its disc. You might even catch a glimpse of its famous Great Red Spot, a hurricane larger than Earth, close to the edge of its disc.

See the gas giant Jupiter, gift-wrapped in bands of cloud and wreathed in bright moons

7. M44, the Beehive Cluster

This next object might be a little tricky, so don't be too hard on yourself if it takes a few attempts to find it, or even if you have to give up and try again another night.

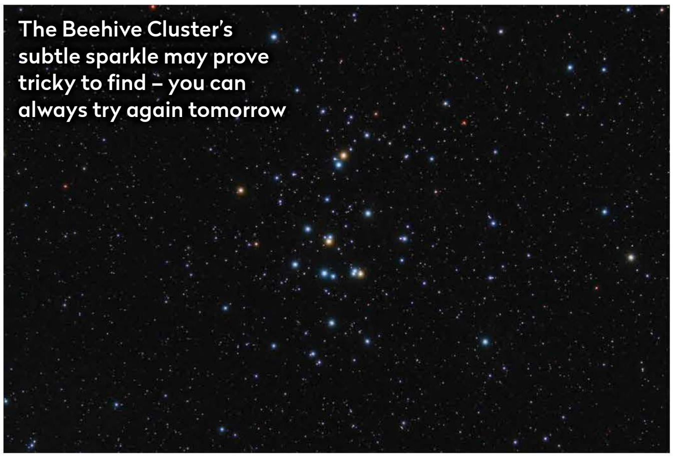
Look to the lower left of Jupiter, around the '7 o'clock' position, and you'll see another fuzzy smudge out of the corner of your eye. This is another star cluster, the Beehive Cluster, also known as Praesepe. Located 610 lightyears away, it's a lot fainter and more spread out than ▶



25 December, 21:00 UT

Find M44, the Beehive Cluster, near the 7 o'clock mark from Jupiter. Low magnifications will give the best view

The M35 star cluster near Castor's 'right foot' is a treat filled with hundreds of gleaming points of light



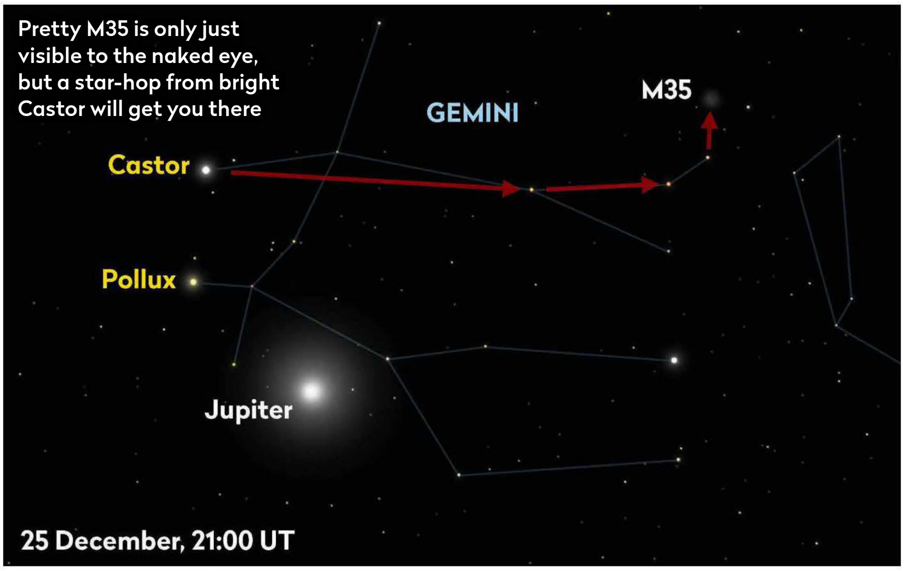
The Beehive Cluster's subtle sparkle may prove tricky to find – you can always try again tomorrow

▶ the Pleiades cluster you saw earlier, but it's still very pretty in a low-magnification eyepiece and definitely worth a look on Christmas night. If you boost the magnification with a more powerful eyepiece, you'll see more stars. However, unlike stars in the Pleiades, the Beehive's members are all quite dim, so low magnifications will give you the best view.

8. M35

Next, look to the upper right of Jupiter, not too far away from the planet, and there in the constellation of Gemini is another very pretty star cluster: M35. For most people, it's on the borderline of naked-eye visibility, so don't worry if it takes some finding on your first night.

To track it down, start from Castor and Pollux, the two brightest stars in Gemini, and star-hop to a line of three stars of roughly the same brightness (as shown on the chart). Just above those stars lies M35, a star cluster more than 3,000 lightyears from Earth. In your low-power eyepiece, M35 will look like a smaller, denser version of M44, the Beehive Cluster you saw earlier. Higher magnification will make it easier to spot by increasing the contrast between the cluster and the surrounding dark sky.



Pretty M35 is only just visible to the naked eye, but a star-hop from bright Castor will get you there

25 December, 21:00 UT

9. M42, the Orion Nebula

Now, look to the right of Jupiter and you'll see an hourglass-shaped pattern of stars, with a line of three blue-white stars across its centre. These stars are Orion's Belt – so, obviously, we're now in the

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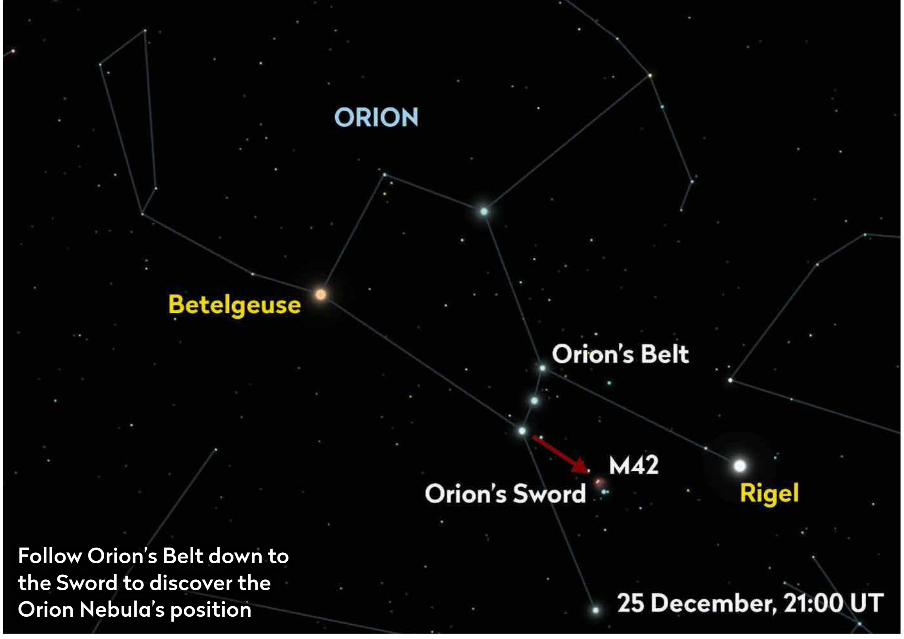
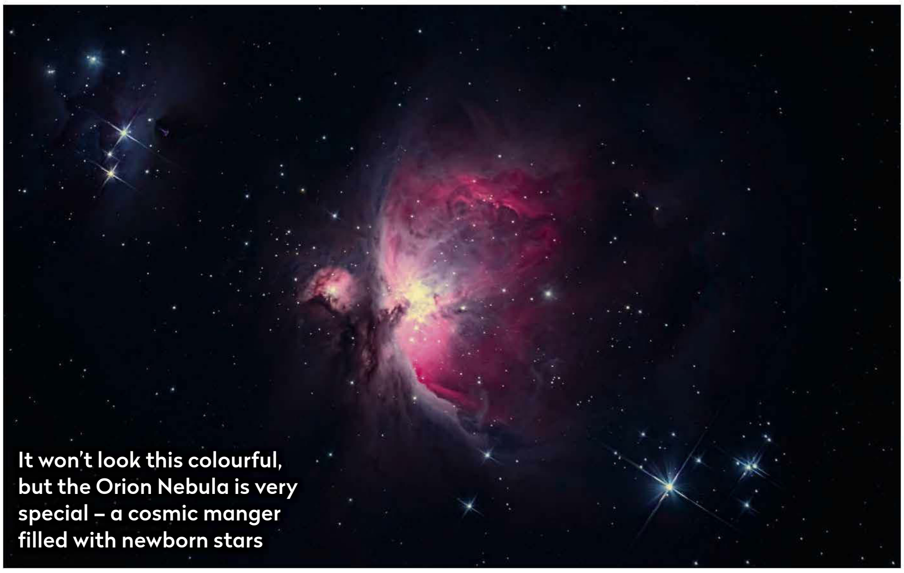
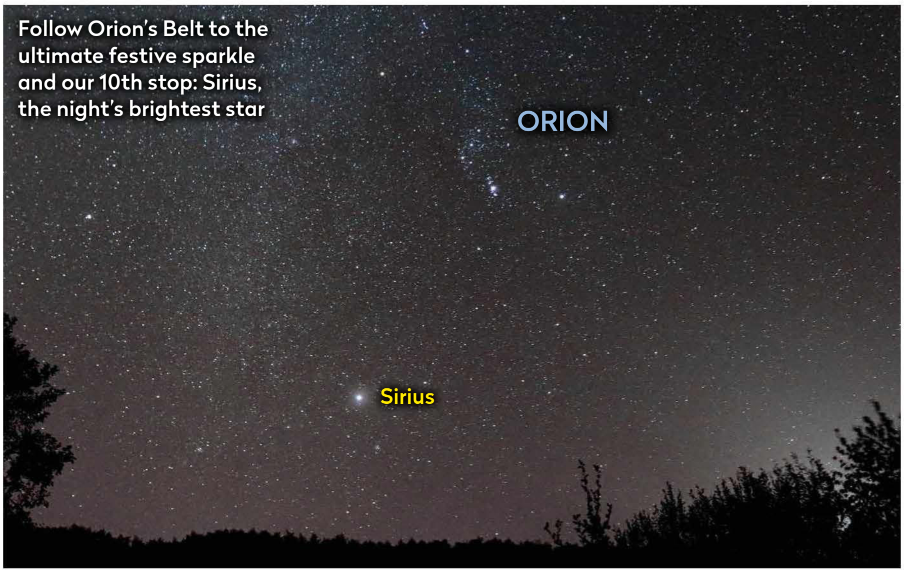


25 December, 21:00 UT

Follow Orion's Belt down to the Sword to discover the Orion Nebula's position



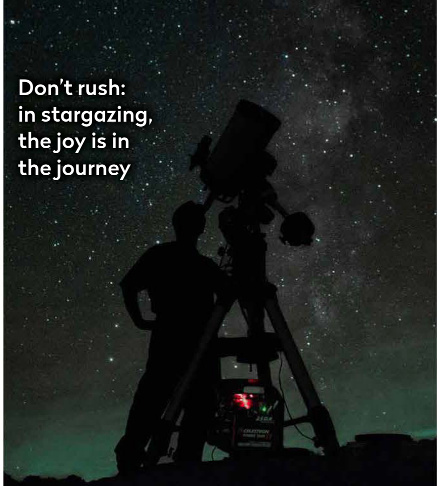
It won't look this colourful, but the Orion Nebula is very special – a cosmic manger filled with newborn stars



Follow Orion's Belt to the ultimate festive sparkle and our 10th stop: Sirius, the night's brightest star

constellation of Orion, the Hunter, the most famous constellation in the northern winter sky.

Looking just below Orion's Belt, on the left you'll see Orion's Sword, a shorter line of three much fainter stars. Aim your telescope at the middle 'star' and you'll discover it's no star at all, but a beautiful, hazy cloud. This is the famous Orion Nebula, a vast cloud of gas and dust 1,400 lightyears away, where stars are being born. You'll have seen its spectacular red, green and purple colour on photographs, but you'll only see it as a very pale grey-green colour through your telescope. Use low magnification for the full sweep, but boost the magnification to see baby stars shining in the heart of the nebula.



Don't rush: in stargazing, the joy is in the journey

First-night frustration

If at first you don't succeed... try and try again

Many of the sights on this Christmas night tour are big enough and bright enough to spot with the naked eye, making them easy – or at least easier! – to track down with your new telescope. But some will be more challenging, and you might not find them all on your first attempt. But that's ok – it's all part of learning how to use your telescope. Every seasoned stargazer you see looking into a complex setup covered in more wires and cables than a nuclear reactor was once a beginner like you. Take your time – you'll get there!

10. Sirius

You've arrived at the final stop on our Christmas night tour, and it's a fitting finale: Sirius, the brightest star in the entire night sky. It might seem a puzzling pick: it's a star, and amateur telescopes can't make stars look any bigger, right? That's true, but this star through a telescope is simply amazing – and that's a good enough reason!

Sirius is only nine lightyears away from us, and you'll find it blazing away low in the southeast with a fierce silvery-blue light, just above the trees or rooftops. Find it by following the line of Orion's Belt down to the left. Through a low-magnification eyepiece, Sirius will be strikingly bright, but switch to a higher magnification and it will be dazzling, shimmering and dancing like a diamond turning in the sunshine.

Stuart Atkinson is the author of 19 books on astronomy. He always looks forward to stargazing on Christmas night

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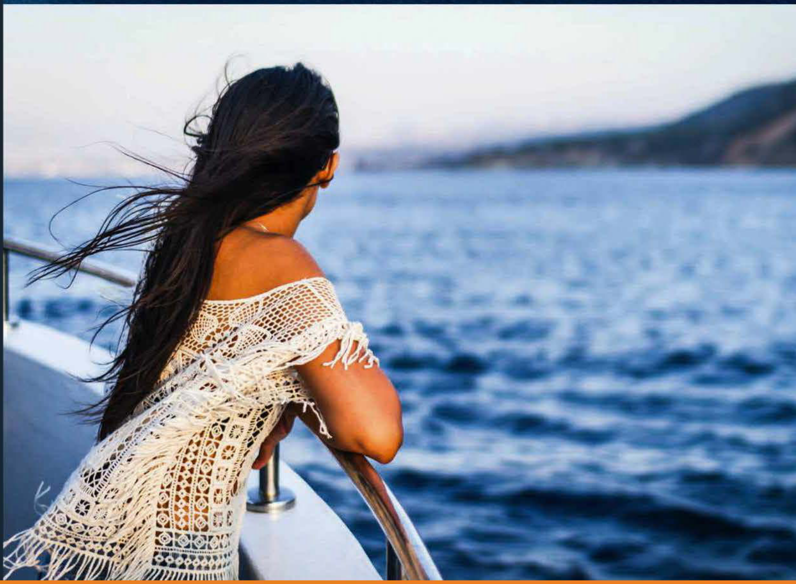

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Did asteroids bring life to Earth?

Nick Spall examines the evidence that life on Earth came from outer space – and how close science is to proving it

Did asteroid strikes sow the first sparks of life on a world still taking shape? We explore the panspermia hypothesis

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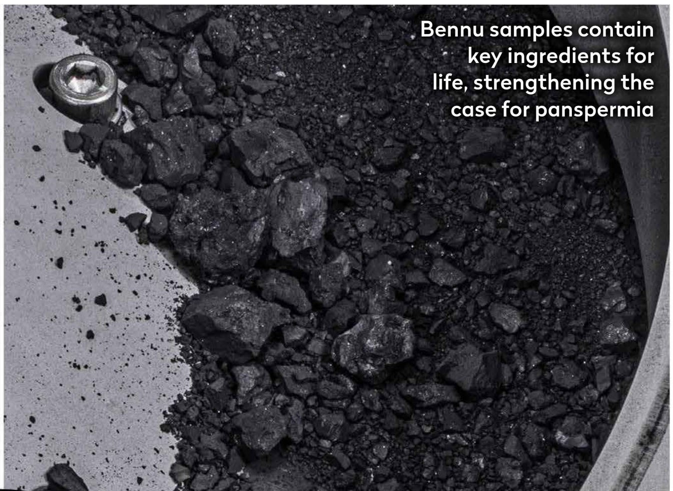
Hayabusa2's sample of asteroid Ryugu revealed organic molecules like uracil and vitamin B3


Bennu samples contain key ingredients for life, strengthening the case for panspermia

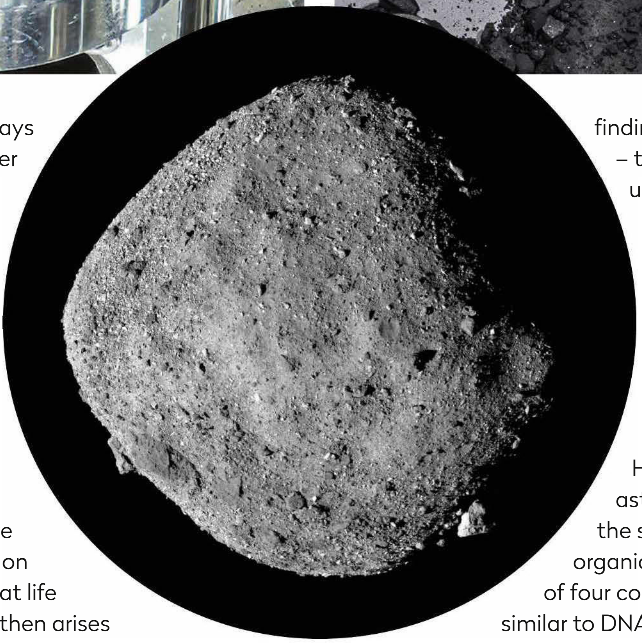
We humans are always wondering whether we're alone in the Universe. But what if we are one of a long line of species that were around long before our planet even existed? This intriguing idea, that life didn't originate on Earth but arrived from elsewhere in the Galaxy, has always been controversial, but it's one that keeps resurfacing. In fact, it's only gaining credence as we uncover more potential signs of life on other planets. If we do find proof that life exists elsewhere, the question that then arises is: did that life evolve separately on each planet, or did it travel there from an earlier source? And if we can entertain the idea that that could have happened elsewhere, why not on Earth?

The 'panspermia' theory asserts that the building blocks of life, or even life itself, were delivered to Earth by piggybacking on a comet or asteroid, kickstarting the evolutionary process that culminates in life existing and, ultimately, you reading this article. It's an idea that's had much derision in the past, so why do so many serious scientists still entertain it as possible fact? What makes it so attractive? Let's have a look at the evidence that supports it…

Organics everywhere

The panspermia theory isn't new. Over 50 years ago, the work of the late Sir Fred Hoyle and Chandra Wickramasinghe argued that microbial life permeates the Galaxy on a vast cosmic scale. Their hypothesis, extending the thinking of 19th-century scientists, including Lord Kelvin and Svante Arrhenius, was that life may be distributed from world to world by meteors, asteroids, dust and comets.

One of the main reasons that the theory has been gaining traction recently is that we are now finding the building blocks of life – the organic molecules that are used to create living creatures – in all kinds of places: on asteroids, on comets, on Mars, on Saturn's moons and in Earth's upper atmosphere. And these aren't rare findings – in fact, they're increasingly common.


▲ **NASA's OSIRIS-REx mission used a Touch-and-Go (TAG) manoeuvre to collect a sample from near-Earth asteroid Bennu**

In November 2019, the Japanese robotic spacecraft Hayabusa2 took samples from asteroid 162173 Ryugu. Analysis of the samples revealed the presence of organic compounds such as uracil – one of four components in RNA (a molecule similar to DNA that plays a similar role in replication in viruses and animal cells) – and vitamin B3. These samples were carefully protected in sealed capsules, so there was little chance of contamination from Earth.

Similarly, in October 2020, NASA's OSIRIS-REx probe took samples from asteroid 101955 Bennu. Analysis revealed the presence of carbon- and nitrogen-rich compounds, including 14 of the 20 amino acids that make up proteins found in Earth organisms, together with all five of the building blocks that make up DNA and RNA – that's pretty much everything needed for life to reproduce.

Of course, simply detecting such molecules on asteroids isn't enough. They must be organised in a way that they can interact with each other. And we need to be able to rule out the possibility that they formed through purely chemical, non-biological processes (a concept known as abiogenesis).

Whether from a life source or not, these molecules could still have kickstarted life on our planet. But for that to be possible, we'd need to show they could remain viable after their journey through the harsh conditions of space, with its high ultraviolet radiation, vacuum and hostile temperatures – not to mention being smashed into Earth at immense speeds.

JAXA | NASA, ERIKA BLUMENFELD & JOSEPH AEBERSOLD | NASA, GODDARD, UNIVERSITY OF ARIZONA | MACIEJ FROLOW, GETTY | NASA, JPL-CALTECH X 2 | ROSCOSMOS

Scooping up spacedust for clues of life

Could a robotic mission capture biological 'seeds' arriving from space?

Convincing tests of the panspermia theory face the need for hard evidence – actual incoming material, perhaps in the form of dormant spores, bacteria or viruses. One way to investigate this would be a dedicated exobiology spacecraft equipped with a collector system.

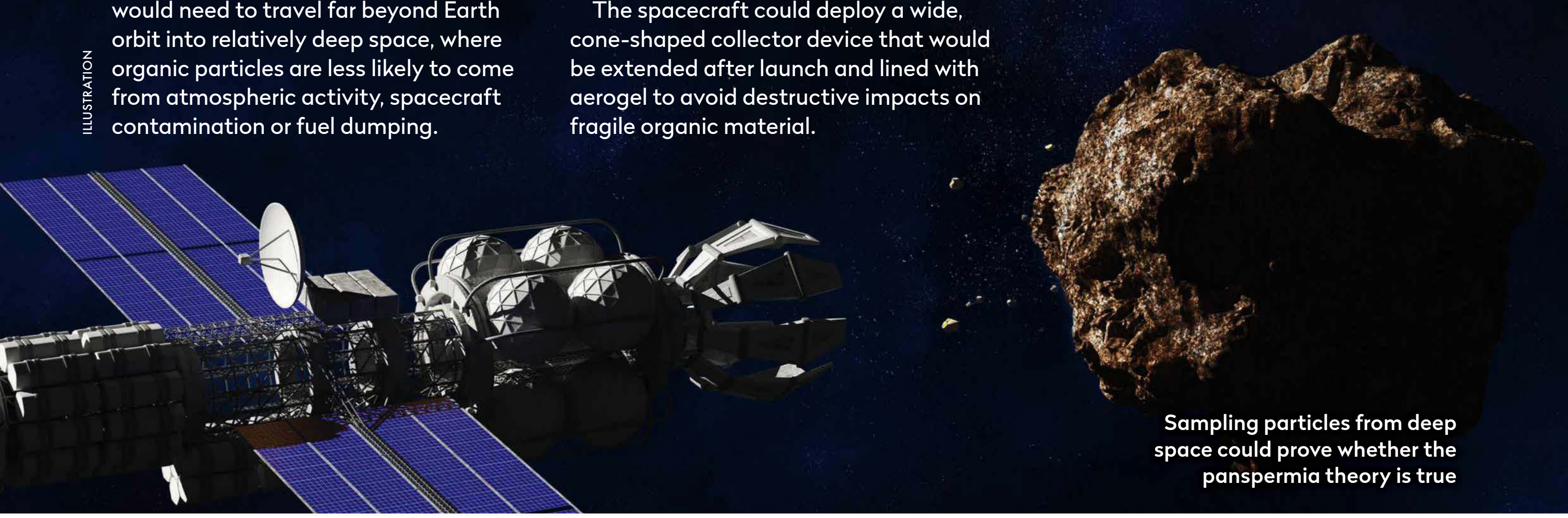
These organics-seeking missions would need to travel far beyond Earth orbit into relatively deep space, where organic particles are less likely to come from atmospheric activity, spacecraft contamination or fuel dumping.

To avoid the same criticisms that the Indian Space Research Organisation's (ISRO) 2001 balloon experiment faced – when some claimed that the high-altitude particles collected were merely molecules that originated on Earth – a long-distance orbit might extend out to 1.6 million km (1 million miles) from Earth.

The spacecraft could deploy a wide, cone-shaped collector device that would be extended after launch and lined with aerogel to avoid destructive impacts on fragile organic material.

The samples could then be sealed in tubes of a similar design to those used in ISRO's balloon sampler mission and returned to Earth using OSIRIS-REx-type re-entry capsules. And perfect sterilisation of the spacecraft would, of course, be vital to ensure results remained uncontaminated.

ILLUSTRATION



Sampling particles from deep space could prove whether the panspermia theory is true

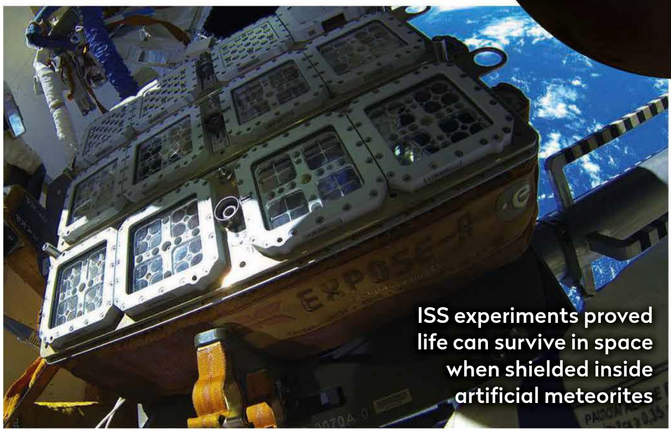
However, experiments on the International Space Station (ISS) as part of the EXPOSE project have now shown that, if protected with suitable meteorite-like material, biological samples could withstand and survive the rigours of entry into Earth's atmosphere. It also found that bacterial spores and even seeds could survive in the harsh vacuum of space.

Did life come from Mars?

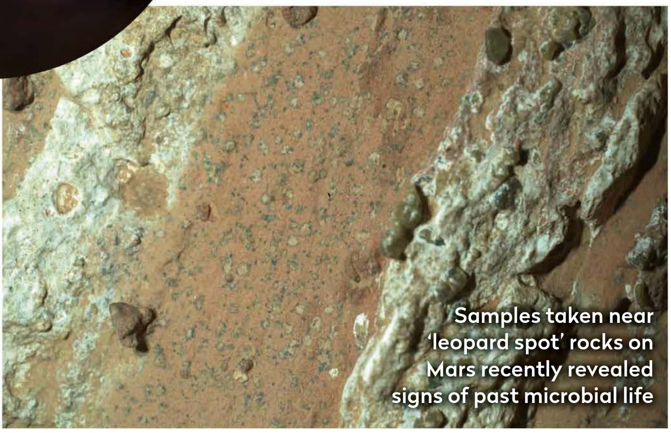
Some scientists have suggested that life on our planet might have been seeded from our nearby neighbour, Mars. In the BBC TV series *Seven Days on Mars,* Professor Brian Cox noted: "We know that material moves from Mars to Earth and from Earth to Mars. It is entirely possible that life began on Mars and was transferred to Earth." This idea is known as lithopanspermia, the hypothesis that extremophile-type microscopic life could survive in debris blasted into space from planetary collisions with asteroids and comets.

In 2024, NASA's Perseverance rover discovered 'leopard spots' on a reddish rock in Jezero Crater, hinting at possible microbial life from Mars's wetter, warmer past. These sediments date to about 4 billion years ago – around the same time that life is thought to have begun on Earth. Rock core samples are waiting in tubes for a sample-return mission to bring them back to Earth for analysis. Only then will we know whether these molecules formed biologically or through inorganic processes alone – and perhaps whether Earth's life story began on Mars.

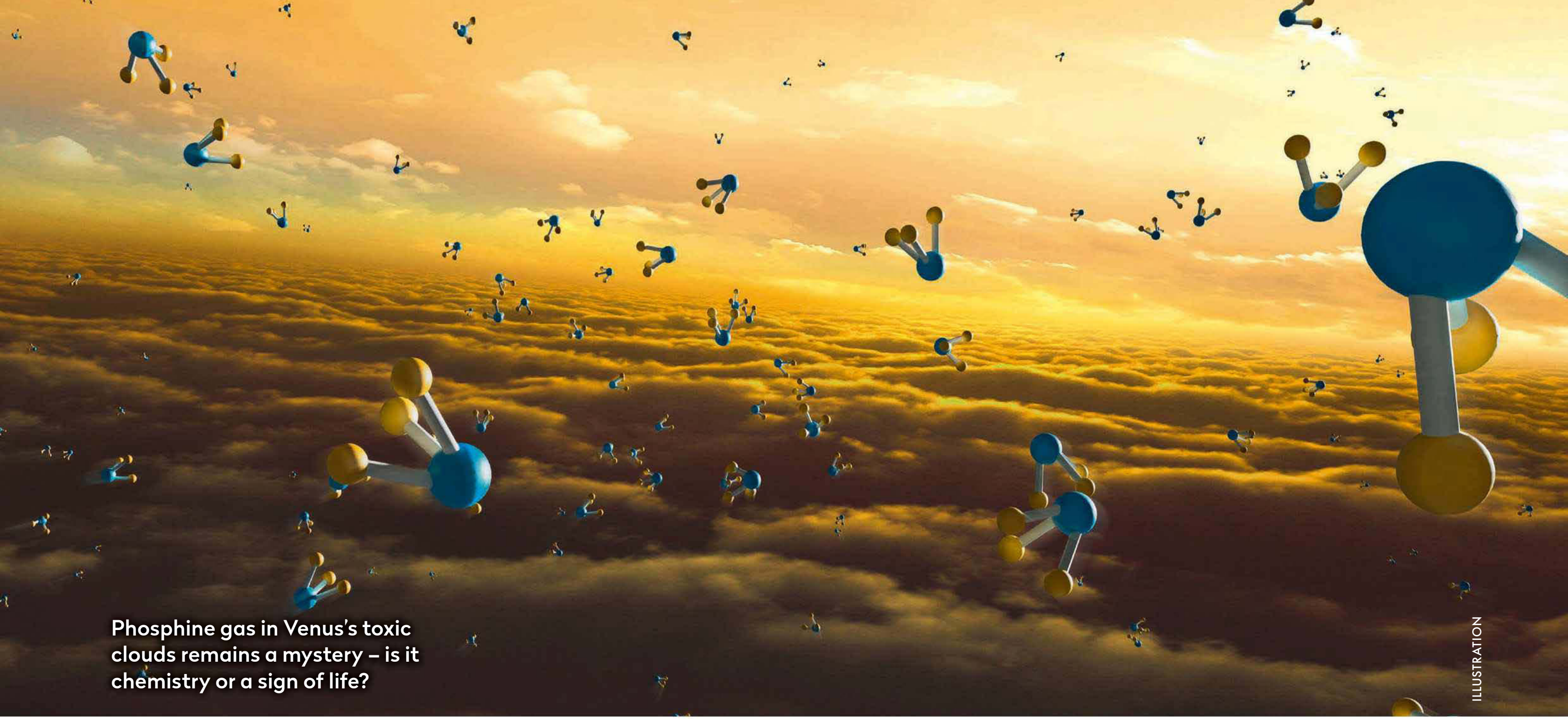
There's been speculation about other locations in our Solar System that could be our source of life, including Saturn's moons. ▶



ISS experiments proved life can survive in space when shielded inside artificial meteorites



Samples taken near 'leopard spot' rocks on Mars recently revealed signs of past microbial life


Phosphine gas in Venus's toxic clouds remains a mystery – is it chemistry or a sign of life?

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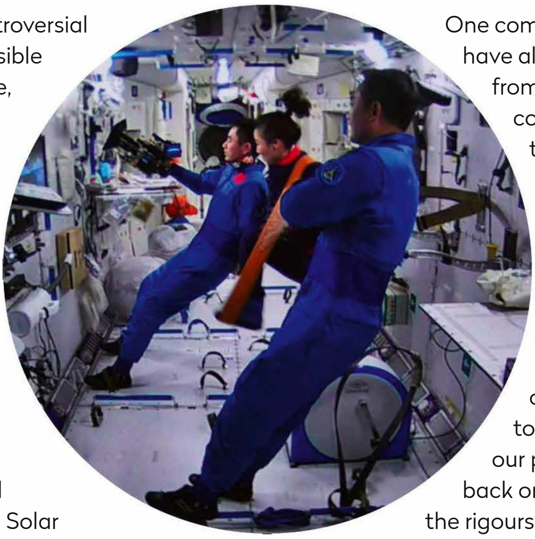
▶ In the high atmosphere of Venus, controversial studies have questioned if there is a possible organic origin to the phosphine gas there, which on Earth has a biological source.

Is all life the same?

If evidence of past or present life is ever found anywhere else in the Universe, whether through exploratory sampling missions or remote spectral analysis, the key test will be whether it has the same constituents as Earth's biochemistry.

As Professor Ian Crawford of Birkbeck University of London explains: "If panspermia has been operating, it will predict that all life found throughout the Solar System will have a common origin and thus share key biochemical characteristics – such as the same genetic code. On the other hand, if life did not travel between planets, we would expect that any life we find would be quite different from our own."


▲ Chinese astronauts found a new bacterial strain aboard the Tiangong Station

One complication is the possibility that we have already contaminated space with life from Earth. In 2017, Russian cosmonauts collected samples from the exterior of the ISS – 400km (250 miles) above the planet – that were claimed to contain 'space bacteria'. These findings are still being debated, but it seems likely they originated on Earth.

Then, in 2023, Chinese astronauts aboard the Tiangong Space Station discovered a previously unknown strain of bacteria living on its hardware. Similar to a bacterium found in soil and food on our planet, it was likely to have originated back on Earth but had adapted to deal with the rigours of living in space. These adaptations included genes for oxidative stress response and radiation damage repair, as well as the ability to form biofilms by breaking down gelatine to extract carbon and nitrogen – strategies that help it survive in a resource-limited environment.

"The case for panspermia is building"

Professor Chandra Wickramasinghe on the latest evidence that life originated in space

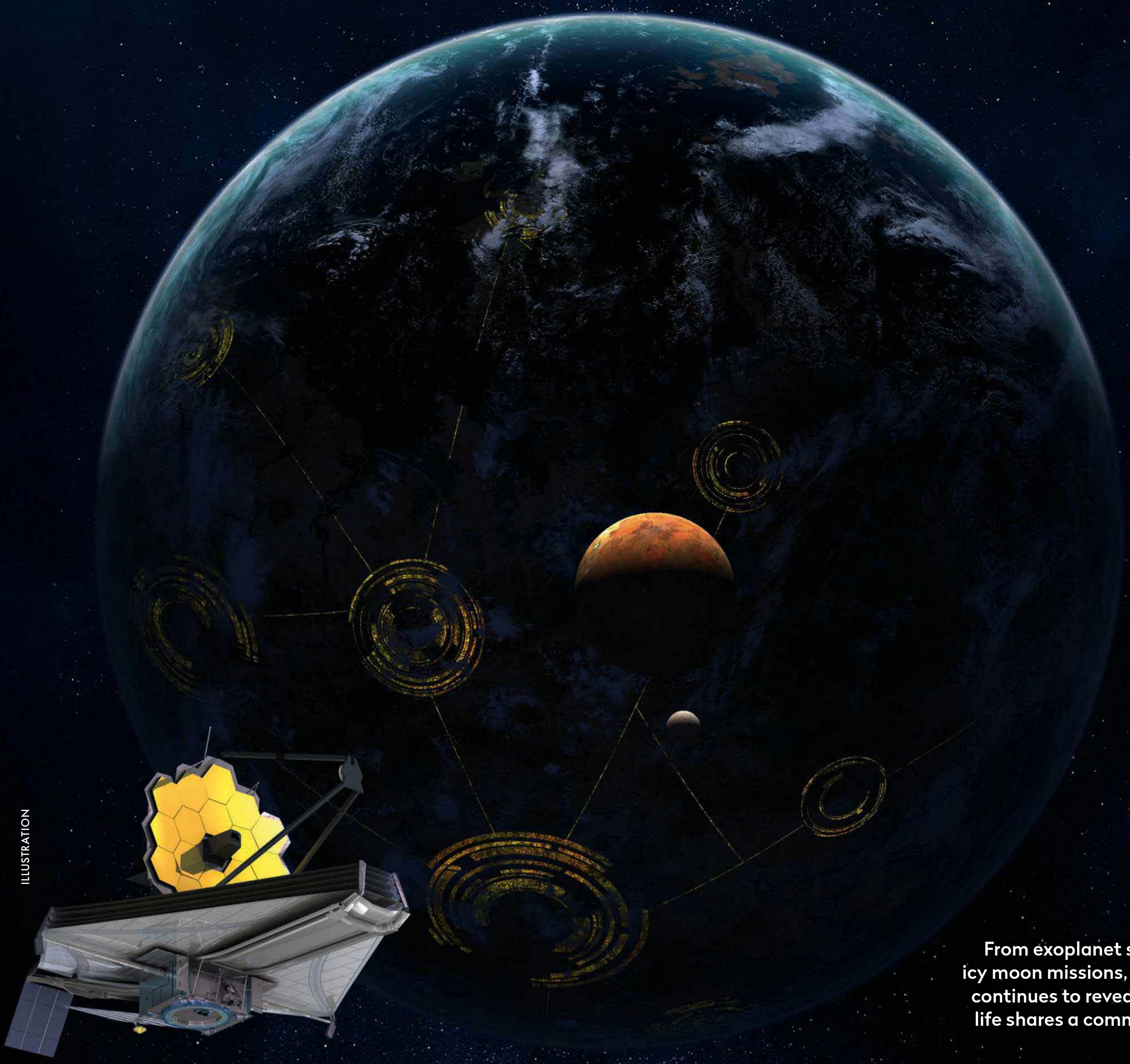
"In my view, and those of researchers like Fred Hoyle, life permeates the Universe and had its origins early on at the centre of the Galaxy. Fred and I made the case for the existence of complex organic building blocks in comets and interstellar clouds back in the 1970s and '80s. We were proved correct.

The case for panspermia is building. The ISRO's 2001 balloon experiments collected samples 30–41km (19–25 miles) above the Earth. These showed new strains of bacteria never seen before.

The survivability of bacteria and viruses in space, as well as plant seeds and even complex life like tardigrades, has been proven via the recent EXPOSE tests on the ISS. Viruses such as the worldwide 1918–19 flu pandemic may have arrived from space – illnesses from that outbreak occurred across the world on virtually the same day, well before intercontinental jet travel.

Current scientific views on the abiogenesis origin of life on Earth is strongly influenced by Western-based cultural and theological views. Eastern-based cultures have less of a problem in this regard. Despite over 50 years of experiments to prove spontaneous generation, using the best-equipped biochemical laboratories in the world, no evidence for such a process has been discovered.

As for proof of panspermia, whilst Carl Sagan said 'Extraordinary claims require extraordinary evidence', I would ask: where is the evidence that extraterrestrial life and panspermia do not occur?"

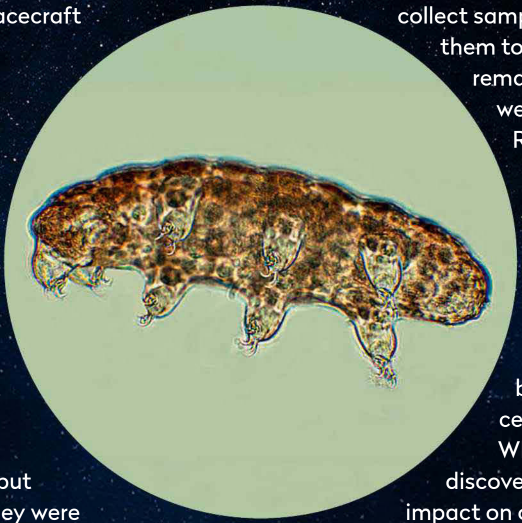


ILLUSTRATION

From exoplanet surveys to icy moon missions, the quest continues to reveal whether life shares a common origin

Despite our best efforts to sterilise spacecraft by ending their missions in a fiery and destructive plunge into a planet's atmosphere, it's possible that some life has slipped through the net accidentally – even complex life forms. Take tardigrades, otherwise known as water bears. These are some of the most resilient creatures on planet Earth. They can survive high levels of radiation, extreme cold, complete vacuum and even a complete lack of water. And thousands of them were part of the cargo on an Israeli space mission that crash-landed on the Moon.

It's likely they were killed in the crash, but some argue that should the container they were stored in have survived the descent, they could be waiting in their dormant state for their chance to colonise the Moon.



▲ Tiny but tough tardigrades survive conditions that mimic deep space

What if we found proof?

New findings about possible alien life regularly make the headlines, thanks to data from missions currently exploring our Solar System and the research on distant exoplanets by space telescopes such as the JWST. However, until we can physically collect samples of active or historic life and return them to Earth, solid proof of its existence remains elusive. And if life were to be found, we would then have to test its DNA or RNA composition to see if it arose independently or shares a common panspermia origin with Earth life.

Even if active microscopic life of a different nature to Earth's is ever discovered, panspermia exponents would inevitably argue that other life elsewhere in the Galaxy could well be the same as Earth's. It may take centuries to reach any real conclusion. Whatever the outcome of the debate, the discovery of life elsewhere will have a profound impact on our science, culture and philosophy. As Arthur C Clarke famously said: "Two possibilities exist: either we are alone in the Universe, or we are not. Both are equally terrifying."

Nick Spall is a science writer who specialises in aviation, spaceflight and astronomy

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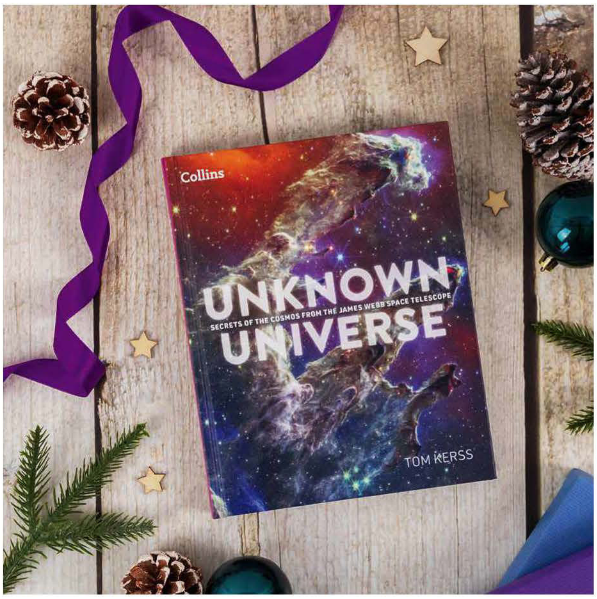
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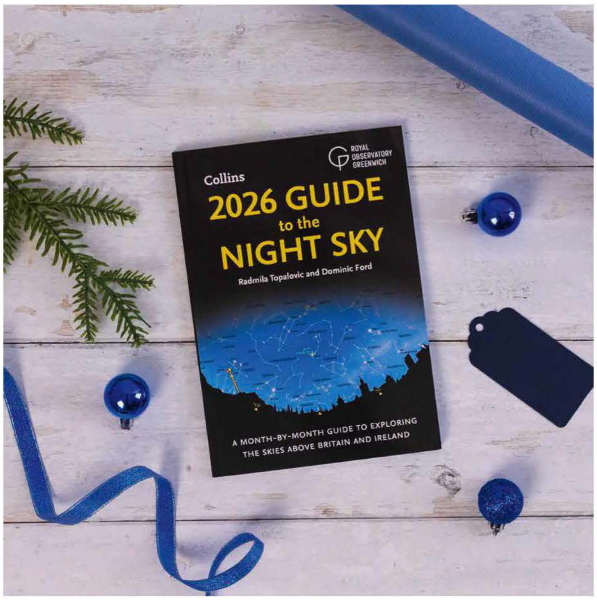
Where to buy: **Argos.co.uk / Currys.co.uk**

2026 GUIDE TO THE NIGHT SKY

Written and illustrated by astronomical experts and approved by the astronomers of the Royal Observatory Greenwich, this is the bestselling stargazing handbook to the planets, stars and constellations visible from the northern hemisphere. With advice on where to start looking, positions of the moon, visible planets and eclipses, constellation charts and a map of dark sky sites, this handy guide is the ideal gift for amateur and seasoned astronomers in 2026.

The *2026 Guide to the Night Sky* (RRP £7.99) is available wherever you buy your books and online at **collins.co.uk/astronomy**

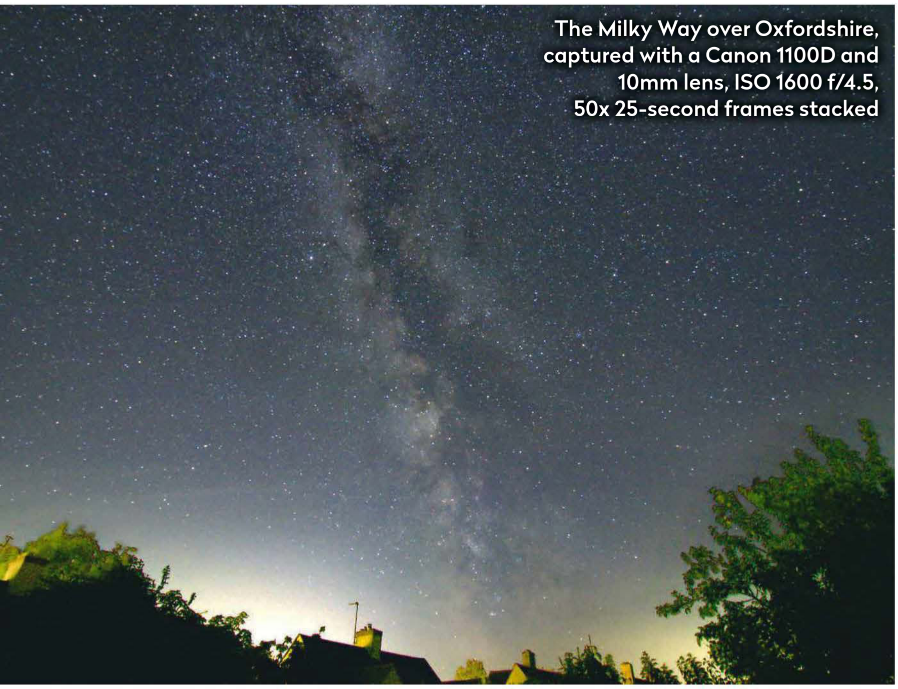

ROYAL OBSERVATORY GREENWICH
Collins
2026 GUIDE
to the
NIGHT SKY
Radmila Topalovic and Dominic Ford
A MONTH-BY-MONTH GUIDE TO EXPLORING THE SKIES ABOVE BRITAIN AND IRELAND

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

Take great photos of the Milky Way

How to capture, stack and process your way to glorious shots of our Galaxy


The Milky Way over Oxfordshire, captured with a Canon 1100D and 10mm lens, ISO 1600 f/4.5, 50x 25-second frames stacked

The Milky Way is a firm favourite for nightscape photographers and astrophotographers alike, but beautiful images of our Galaxy are well within reach of beginners with basic entry-level equipment too. While a longer focal length will capture specific regions such as nebulae, here we'll show you how a wide-angled lens and short, untracked exposures can capture more of the Milky Way at once and achieve stunning results.

There are several advantages to shorter exposures. They reduce the chances of capturing unwanted aircraft, satellites or light pollution. They can also be taken without a specialist tracking mount, so there's less equipment to carry and set up. And when it comes to photographing the Milky Way near the horizon, short exposures won't blur the foreground, so you can skip the step of having to blend separate background and foreground photos.

ALL PICTURES: MARY MCINTYRE

Be prepared

Start with a little planning. To determine what time of year is best for capturing different regions of the Milky Way from your location, try a planetarium app such as Stellarium. Shooting on a moonless night is preferable. You'll need to work out the correct exposure length for your lens. The longer the focal length, the shorter the exposure needs to be to keep your stars sharp.

To get a ballpark exposure time for your lens, use the '500 rule'. Start with the number 500 and divide it by the focal length of your lens. This gives you the approximate number of seconds you can expose before the stars will start to trail. For example, if you're using a 10mm wide-angled lens, 500/10 = 50 seconds; for a fixed 50mm lens, 500/50 = 10 seconds.

This number applies to a full-frame camera; if your camera has a cropped sensor, the exposure time needs to be reduced by multiplying your focal length by 1.6. Another thing to consider is that the farther that stars lie from the celestial pole, the faster they appear to move in any given period. Near the celestial equator, stars appear to move faster, so the exposure time needs to be much shorter. When imaging the Milky Way near the horizon with a 10mm lens on a cropped sensor, 25 seconds is a realistic exposure time, or 8 seconds with a 50mm lens. Take some test images and check them for trailing.

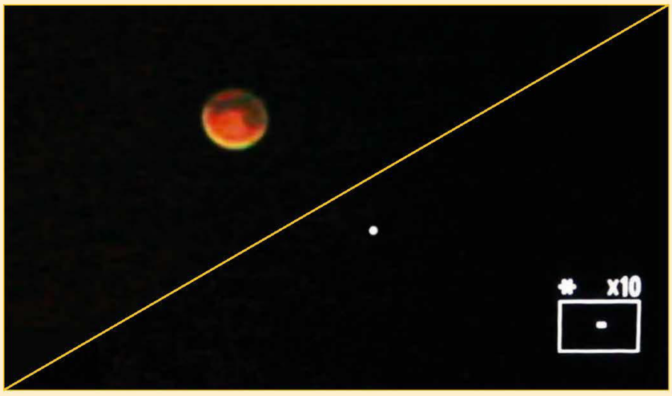
While you may not get huge amounts of detail from a single 25-second shot, you can stack several identical exposures using free software such as Sequator. Stack 12 photographs, for example, and you've effectively captured five minutes of light. Stacking will also decrease any noise in your image. Sequator has built-in tools to reduce light pollution and 'freeze' your foreground to prevent blurring too. You can further reduce noise by including dark calibration frames, a set of images taken at the end of your session using the same settings but with the lens cap on.

Mary McIntyre is an outreach astronomer and teacher of astrophotography

What you'll need

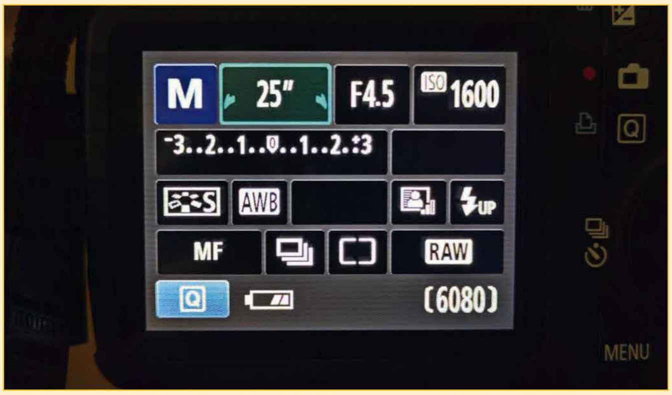
- ▶ DSLR/mirrorless camera with Live View mode and compatible lenses. An astro-modded camera will capture more red near the core, but isn't essential. We used a standard Canon 1100D with 10mm wide-angle lens
- ▶ Tripod with an adjustable locking head
- ▶ Remote shutter cable to prevent camera shake
- ▶ Stacking software, such as the free program Sequator
- ▶ Image-processing software, such as FastStone Image, Photoshop, Affinity Photo or ON1 Photo RAW

Step by step



Step 1

Attach your camera to a tripod, set it to manual focus then point it at a bright star or planet. Use the Live View on 10x zoom and manually adjust the lens focusing ring until the star changes from a blurry disc to a small, focused dot.

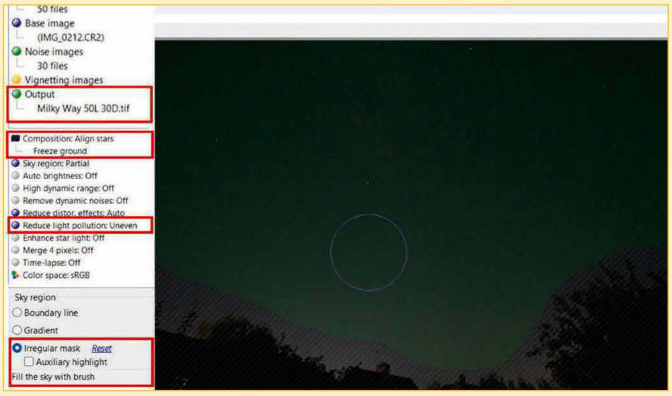


Step 2

Point the camera at the Milky Way, then set it to manual. Select 'Raw' as the format, a low f/stop, an ISO appropriate for your sky conditions and a shutter speed appropriate for your lens. We used a 10mm lens at f/4.5, ISO 1600 and 25-second exposures.

Step 3

Take some test shots and review them to check the settings are correct. If you're happy with the images and there's no visible star trailing, now capture a sequence of images. Once done, replace the lens cap and take about 20 dark calibration frames.

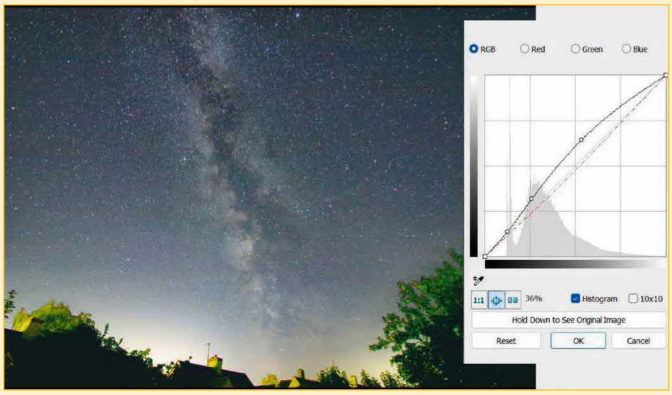


50 files
Base image
(IMG_0212.CR2)
Noise images
30 files
Vignetting images
Output
Milky Way 50L 30D.tif
Composition: Align stars
Freeze ground
Sky region: Partial
Auto brightness: Off
High dynamic range: Off
Remove dynamic noises: Off
Reduce distor. effects: Auto
Reduce light pollution: Uneven
Enhance star light: Off
Merge 4 pixels: Off
Time-lapse: Off
Color space: sRGB

Sky region
○ Boundary line
○ Gradient
● Irregular mask Reset
☐ Auxiliary highlight
Fill the sky with brush

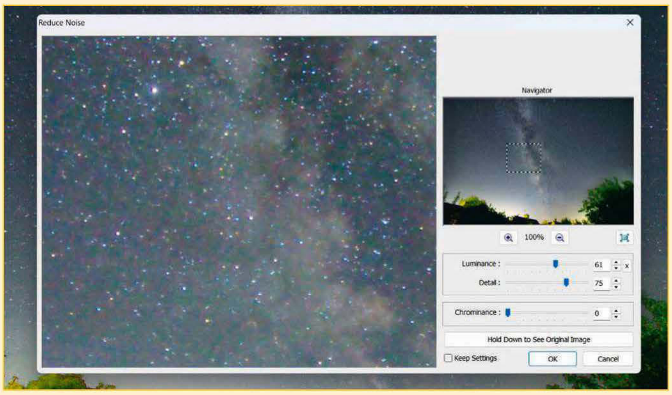
Step 4

Use Sequator to stack your images and dark frames. Select 'Freeze ground' if you have foreground detail and 'Irregular mask' to paint out the sky area. Select the 'Reduce light pollution' option if needed, then name the output file before clicking 'Start'.



Step 5

Process the output file in your favourite software. Adjust Levels to brighten the image, and Curves to selectively brighten the Milky Way detail while preserving the black and white points. Apply several small adjustments rather than one aggressive one.



Luminance : 61
Detail : 75
Chrominance : 0

Step 6

You can use FastStone's lighting and colour options to make final adjustments to tone, colour balance and saturation. Finally, you can use the denoise option to help remove noise or texture in the background. You can now save your first Milky Way image.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

How to photograph the Geminids

Dramatic meteor photos aren't just down to luck. We show you how to bag one

▲ **Just choose the right lens and settings (and warm clothes!) and you'll be capturing Geminid meteor trails in no time**

It's December, which means it's time for the best meteor shower of the year – the Geminids. Perseids fans may disagree, but long, dark nights and a broader activity peak give the Geminids the edge. True, December nights are much colder, so perhaps the Perseids in August win the popularity contest!

Whichever's your favourite, neither wins if the Moon is around. This year's Perseids were ruined by a bright Moon, but 2025's Geminids will fare better. With the Moon just past last quarter as the Geminids peak, its glare should be easy to contain.

Photographing meteors isn't too hard; the tricky part is maximising your chances of capturing a trail. That's why showers like the Perseids and Geminids are so good to try to photograph. If the weather is kind and the Moon out of the way, you'd be very unlucky not to capture anything – though it can still happen!

Pick the right lens

So how can you maximise your chances? A fish-eye lens gives you total sky coverage, so any bright meteor will be recorded. The problem is that fish-eye trails tend to be rather puny and difficult to see. In contrast, something like a 200mm lens would give you excellent meteor trails, but covers so little sky that you'd need to be extremely fortunate to bag one. Somewhere in between is best – typically around the 20mm mark.

Lens speed is important too. This is indicated by the lowest focal ratio (f/number) your lens allows – the smaller the number, the more light passes through. Aim for f/3.5 or faster (lower). But note: many lenses create distortions at the edge of the frame when set to their lowest f/number. Your choice is: set the f/number higher than minimum, lose the distortions but raise the brightness threshold and miss fainter meteors; or, fully open the lens, accept some edge distortion, and capture more numerous and fainter meteors.

Where to aim

Another key question is where to point your camera. To maximise your chances of capturing a trail, we recommend not including any foreground objects in the frame. Aim two-thirds up the sky for the best balance: lower down, a thick layer of atmosphere causes extinction; directly overhead, extinction is minimised but the thinner air results in slightly fewer meteors. Aiming your camera at a position around 60° altitude is a good compromise.

In terms of cardinal direction, pointing straight towards the shower's radiant will result in shorter meteor trails, but also best shows how those trails appear to emanate from a single area of sky. Aiming 40°–60° either side of the radiant will capture longer trails, but don't worry – any clear patch of sky can deliver results.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: DSLR camera (or equivalent) with a 20mm or shorter focal length fast lens

✉ **Send your images to:**
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

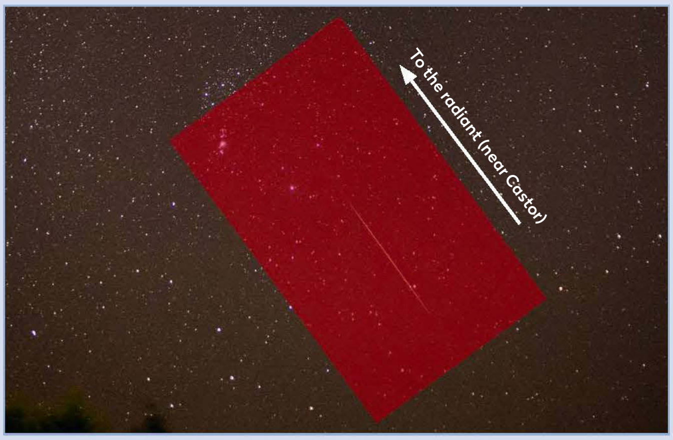
Step by step

STEP 1

Select your kit and have it ready for action. A DLSR or equivalent with a fast lens around 20mm focal length should give decent results. Have plenty of charged batteries to hand, SD card storage and a lockable or programmable remote shutter release cable. If you have more than one camera, rope that in as well.

STEP 2

You don't need any fancy mounting options for your camera. Even just wedging it against something will work. However, for more flexibility, a tripod works best. Keep it mid-height for stability and to make it easier to access your camera. The final piece of the jigsaw is a 12V travel hair dryer or a dew-heater band, to keep moisture off your lens surface.



STEP 3

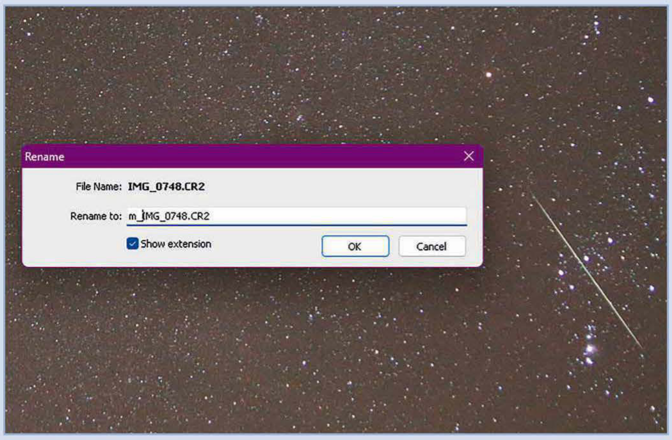
Set the camera's clock to the correct time. Centre the camera on a position approximately 60° above the horizon. Choose which cardinal direction you prefer and orient the camera so the long axis of the frame points back towards the approximate radiant position, near the star Castor (Alpha Geminorum).

STEP 4

For fixed-tripod setups, the orientation recommended in Step 3 will drift during the night. Realign about once an hour to keep the right area in frame. Use that break to check battery life, SD card storage space and any moisture build-up on the lens by shining a torch across it. Although this will ruin the current frame, a fully dewed-up lens won't capture anything either!

STEP 5

Use a mid-level ISO setting, fully open the lens and set to manual focus. Focus on a bright star or Jupiter, then take a short test exposure. If possible, tape the focus ring to prevent accidental knocks. Take a 30-second exposure and check it: bright is fine but not overexposed. If it is, shorten the exposure and retest.



File Name: IMG_0748.CR2

Rename to: m_IMG_0748.CR2

☑ Show extension

STEP 6

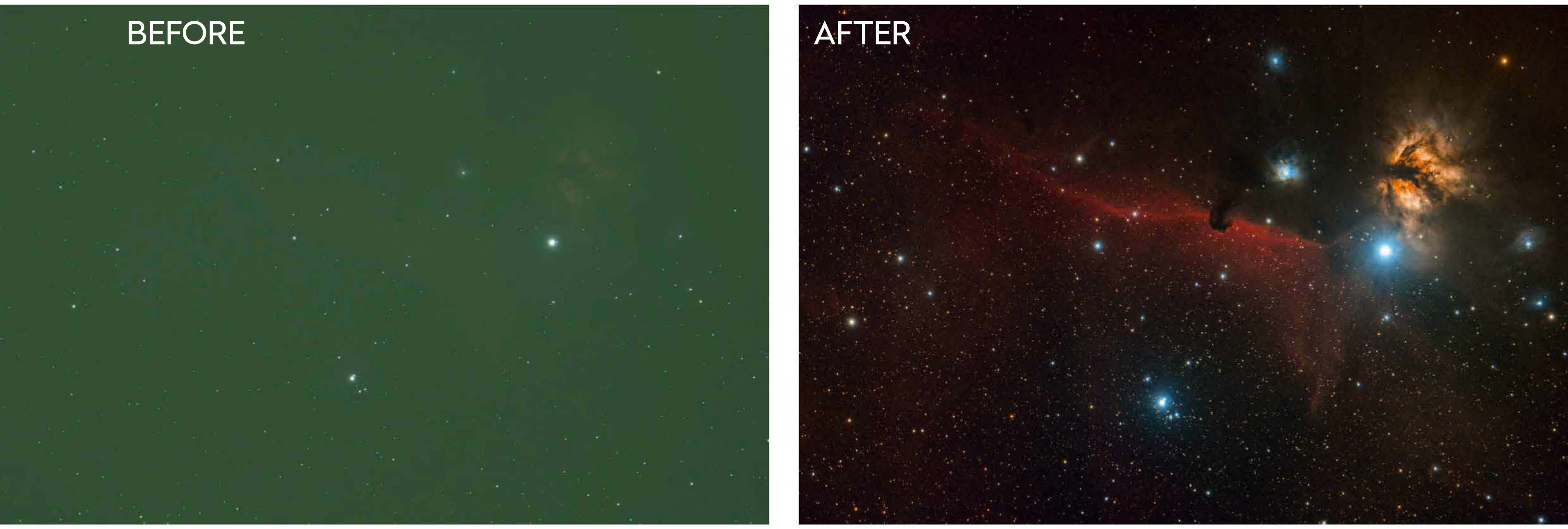
Capture for as long as you can. Download the images to your computer and review them looking for trails. Freeware such as FastStone Image Viewer is ideal for this. If you see a trail, rename those files with the prefix 'm_'. Once done, sort the images and all the trail shots will be grouped together.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Make your dark nebulae shots shine

Use Affinity Photo to unlock the hidden drama in stunning detail



▲ **From 'where?' to 'wow!': Dave's original stacked image (left), built from 23x 120-second subs, hid the Horsehead Nebula in the murk. After careful processing with Affinity Photo (right), the dark silhouette and nearby reflection nebula burst into colour and detail**

Dark and reflection nebulae are among the trickiest targets for imagers. Teasing out details so that they stand out from the background sky, especially through bad light pollution, can be tough, and even specialist filters often don't help. How you process dark and reflection nebulae is therefore key.

Because they aren't brightly illuminated or ionised by embedded stars, dark nebulae often just look like dark patches against a rich, starry Milky Way. Reflection nebulae too don't emit their own light – they're only visible due to starlight hitting them before being reflected back towards us. As this is scattered light, these nebulae have a distinct blue colour and are often fainter than emission nebulae, which emit light at the red end of the spectrum.

We'll walk through how to use Affinity Photo to process a dark nebula image – in our case, the Horsehead Nebula, Barnard 33. Our start image (above) was a stacked set of 23 exposures combined with darks, flats and bias calibration frames, which helped reduce image noise and gradients.

Given the light pollution at our location, this stacked, unprocessed image left a lot to be desired. However, with careful processing it's possible to reveal not only more of the dark Horsehead Nebula, but also the nearby faint reflection nebula NGC 2023. Patience is the key to processing perfection: these targets reward subtle enhancement rather than heavy-handed stretching, which often increases the amount of noise visible.

Time for the reveal

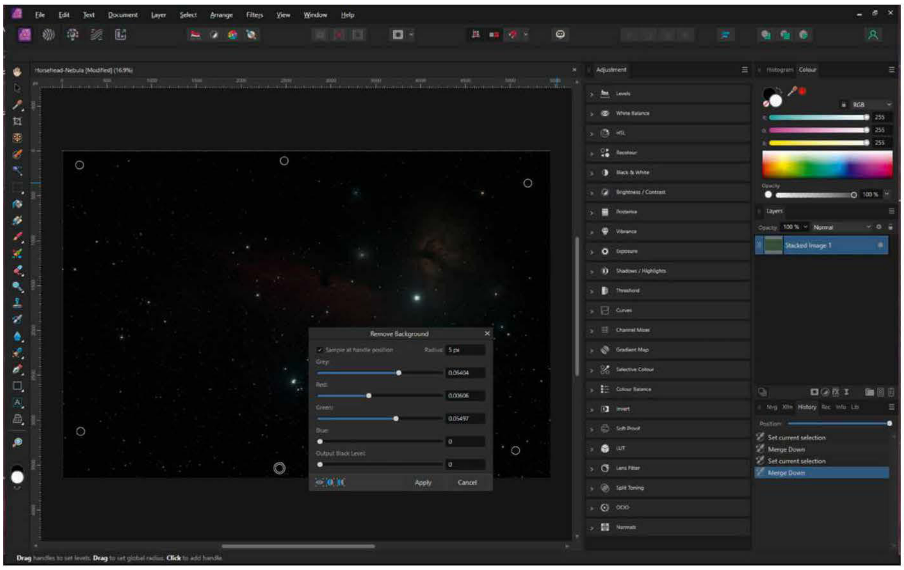
From Affinity Photo's top menu, select File › Open. Browse to the folder where your images are stored and select the stacked image, which will open within Photo Persona. Only brighter stars and brighter nebulae can be seen due to the bright background. You'll need to make a few adjustments to reveal the fainter nebulae.

Start to remove this bright background by clicking Menu › Filters › Astrophotography › Remove Background (see Screenshot 1). Select 'Sample at handle position' from the window to select the colour and brightness to be removed. A circle, called the handle, will appear on the image. Hold this with the mouse and move it to part of the image where it does not sit above any nebulosity or stars. If the image has a severe light gradient, extra handles can be added by clicking on the image.

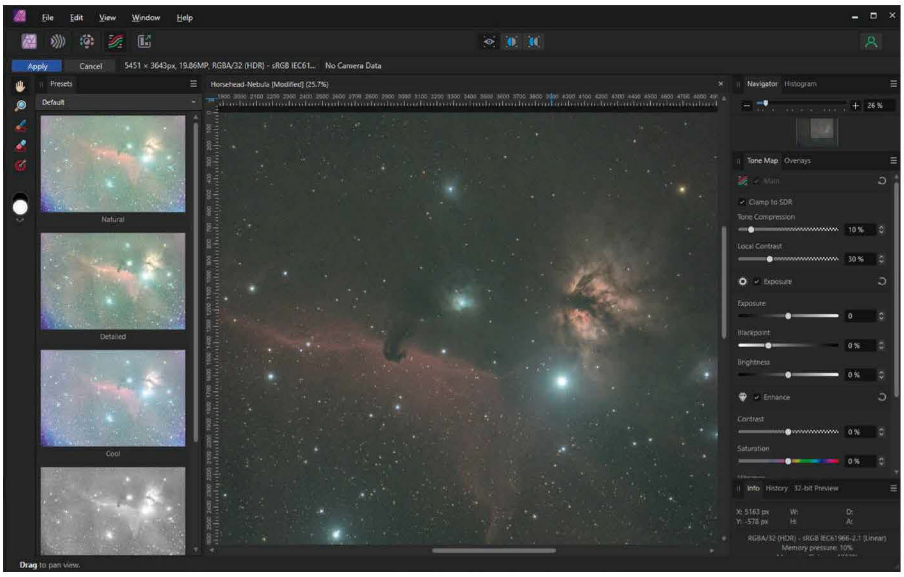
Once the handles are correctly placed on your image, the background will appear darker. To prevent clipping the black point in the image, slightly move the 'Output black level' slider to the right, before clicking Apply.

You'll need to stretch your image to bring out fainter objects without making

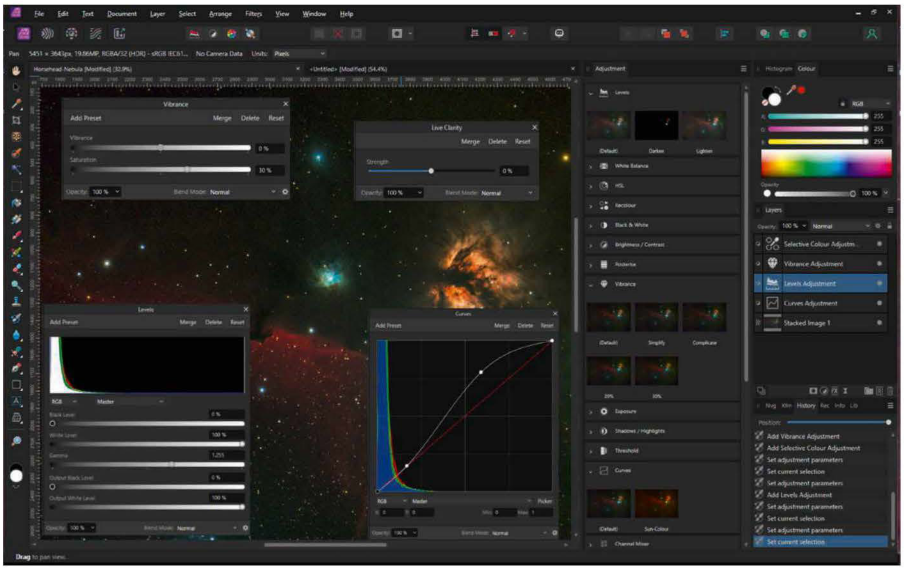
ALL PICTURES: DAVE EAGLE



▲ **Screenshot 1: first, eliminate the bright background using Affinity Photo's background extraction tool. Add 'handles' to set which unwanted colour and brightness to remove**



▲ **Screenshot 2: use Tone Mapping Persona to retrieve faint, dark details without making the brighter parts too white. Tone Compression and Local Contrast allow you to fine-tune**



▲ **Screenshot 3: make your image sing by using Affinity Photo's range of adjustment options to boost contrast and vibrance, sharpen the details and bring out more colour**

3 QUICK TIPS

1. Use long exposures and calibration frames to capture faint nebulae. Accurate guiding is essential for the best results.

2. Make several gentle adjustments rather than fewer, larger steps to achieve subtler images.

3. Create duplicate layers to make adjustments, then use that layer's opacity to obtain finer control over the effect.

the brighter parts of the image too white. The best tool for this in Affinity Photo is the Tone Mapping Persona, opened with the button at the top left of the screen (see Screenshot 2).

Tone Map Persona will initially overstretch your image and look horrendous, but don't panic. Tick the 'Clamp to SDR' box to limit the output values to stop it from brightening the white end, then move the top Tone Compression slider to the left. Slide the Local Contrast slider to the right. We used 10 per cent and 30 per cent. Click Apply.

Next, we want to boost contrast and colour. Under the Adjustment tab, use Levels and Curves to achieve extra contrast, and the Vibrance saturation adjustment to bring out more colour (see Screenshot 3). The image may still have a green cast, which can be removed using the Selective Colour adjustment. Select Green from the Colour drop-down menu, then move the top Cyan slider to the left to reduce the amount of green.

Enhance the blue in reflection nebulae by selecting Blues from the drop-down menu and sliding the Cyan slider to the right. Depending on the data, other colours can be adjusted. Increase sharpness by selecting Layer › New Live Filter Layer › Sharpen › Clarity. Move the Strength slider slightly to the right. For the best results, apply several light touches, rather than one big one. Finally, save your finished image as a new file by clicking Menu › File › Export.

Dave Eagle is an astronomer, astrophotographer, planetarium operator and writer

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

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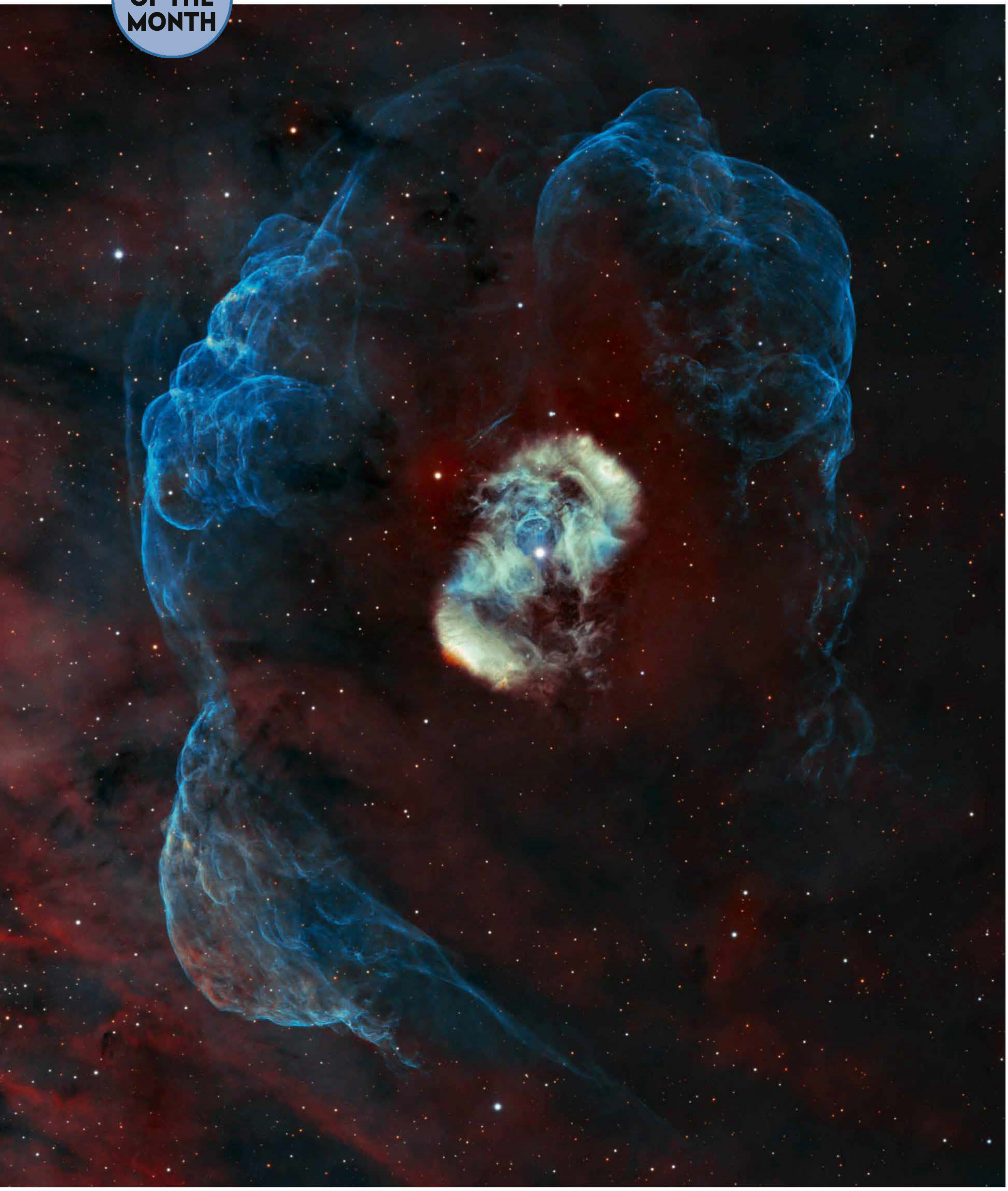
PHOTO OF THE MONTH



◁ Emission nebula NGC 6164

Cecil Navick and Francis Bozon, captured remotely via Obstech, El Sauce Observatory, Chile, 4 May–28 June 2025

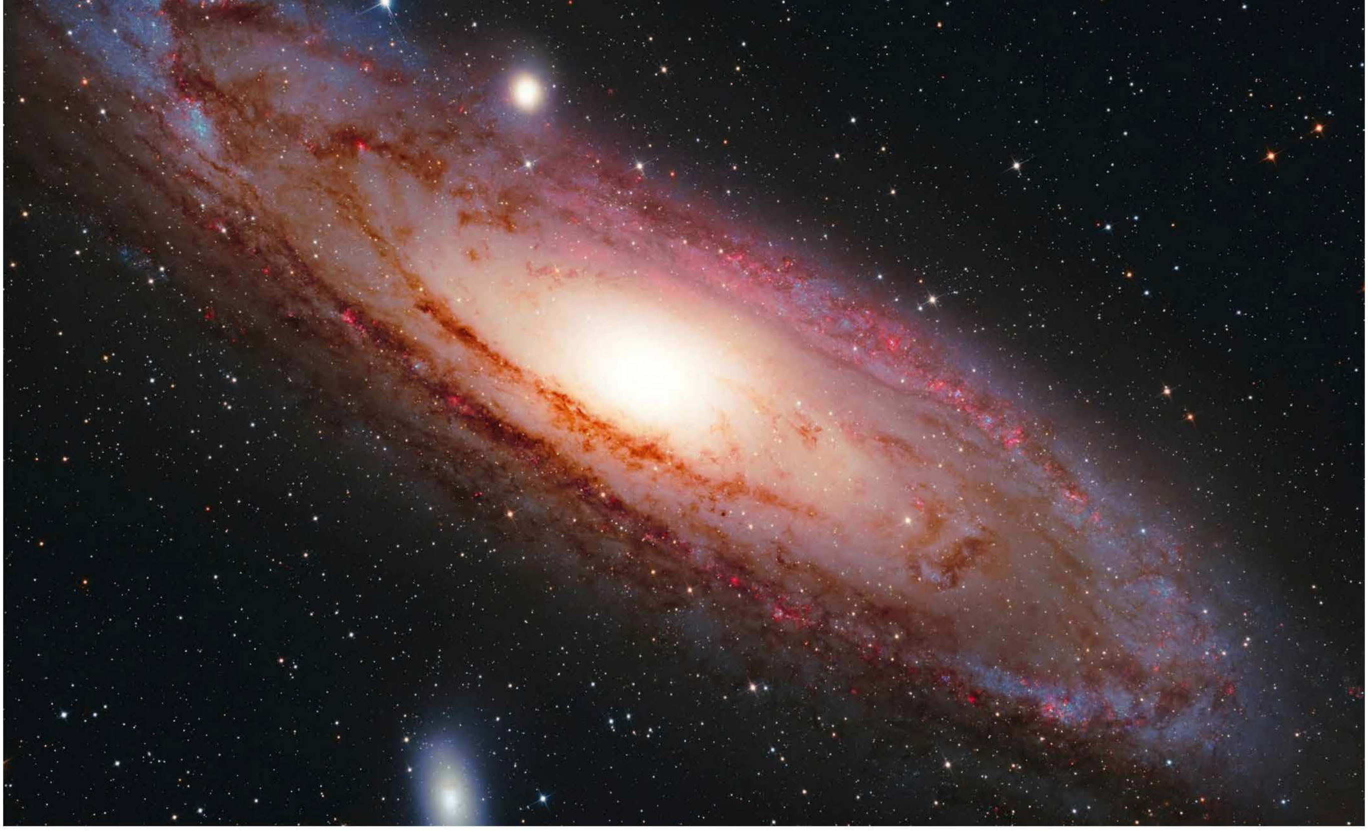
Cecil and Francis say: “We chose NGC 6164 because it’s rarely photographed, plus it’s a target well suited to our scope’s focal length and the camera’s highly sensitive sensor.”

Equipment: ZWO ASI6200MM camera, PlaneWave CDK14 astrograph, Mathis MI-750 mount

Exposure: 118h total

Software: PixInsight, Astro Pixel Processor, Photoshop

Cecil and Francis’s top tips: “For this type of object, we needed long exposures of 600 seconds, with selective filters to bring out the maximum signal. Substantial exposure time is essential; in this case – once we’d sorted through the best images – 118 hours!”



△ The Andromeda Galaxy

Jayden Winson, Hilton, Derbyshire, UK, 21–28 September 2025

Jayden says: "I chose M31 on one of those rare clear, moonless nights. I like how the broadband and narrowband data came together to produce a vibrant image."

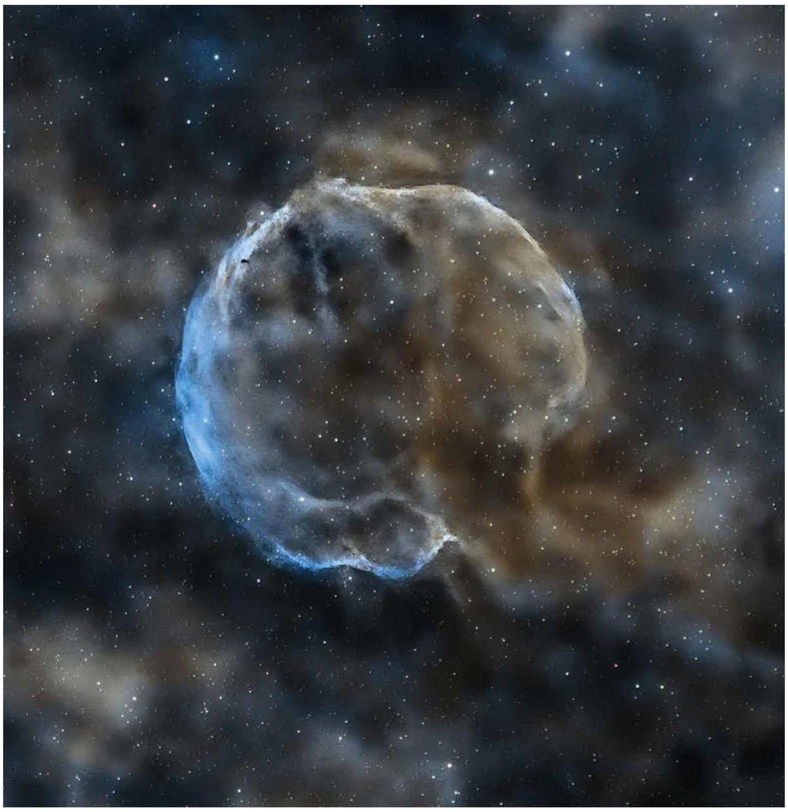
Equipment: ZWO ASI2600MC Pro camera, Sky-Watcher Explorer 150P-DS reflector, Sky-Watcher EQ6-R Pro mount **Exposure:** 40h total **Software:** PixInsight

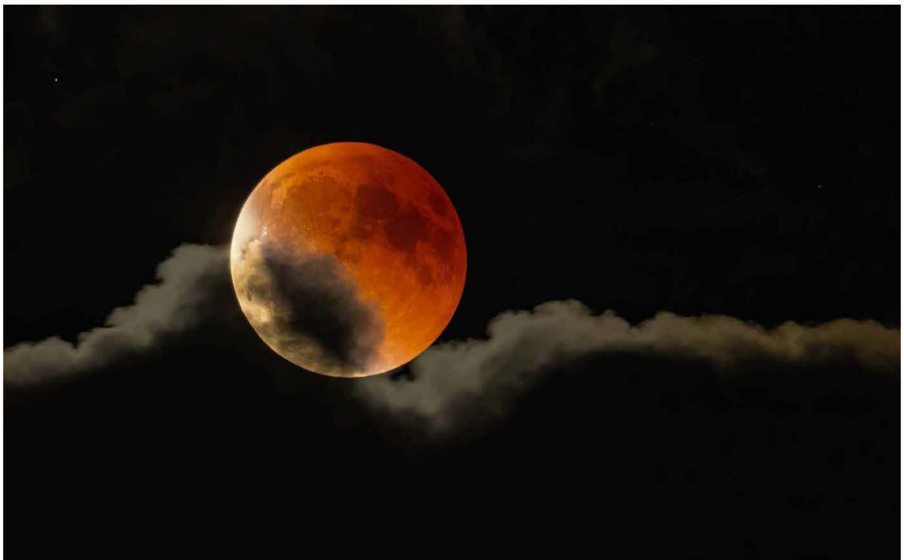
The Garlic Nebula, Abell 85 ▷

Neil Wilson, Terrington St Clement, Norfolk, UK, 22 September 2025

Neil says: "I'd been keen to photograph this nebula for a while. Using a dual-band filter enabled me to highlight Ha in gold and OIII in blue, and I'm pleased with the results."

Equipment: Altair Asto Hypercam 26C camera, Celestron EdgeHD 9.25-inch Schmidt–Cassegrain, Sky-Watcher AZ-EQ6 Pro mount **Exposure:** 77x 90" **Software:** Photoshop, Siril, StarNet++



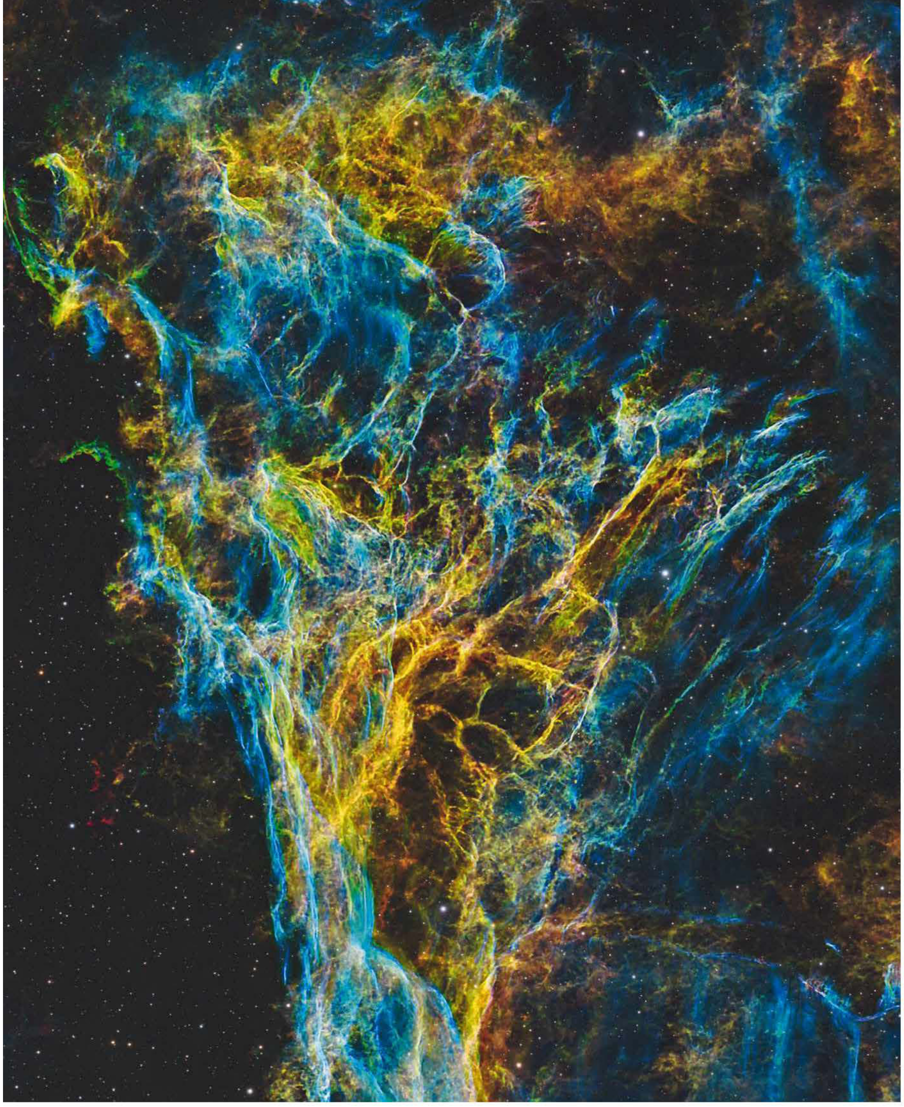


◁ Lunar eclipse

Andrea Georgievova, Mount Ještěd, Czech Republic, 7 September 2025

Andrea says: "I mostly do wildlife photography, but I didn't want to miss this opportunity. There was a lot of cloud cover, but after half an hour the Moon appeared in all its glory."

Equipment: Olympus OM-1 camera, Zuiko 150–600mm lens, Sirui Traveler 5AX tripod **Exposure:** ISO 8000 f/6.3, 0.5" **Software:** Photoshop



◁ Fleming's Triangular Wisp

Craig Dixon, Scarborough, North Yorkshire, UK, 8–28 September 2025

Craig says: "I captured SII, Hα and OIII to present this in the Hubble colour palette – a bit different from the norm."

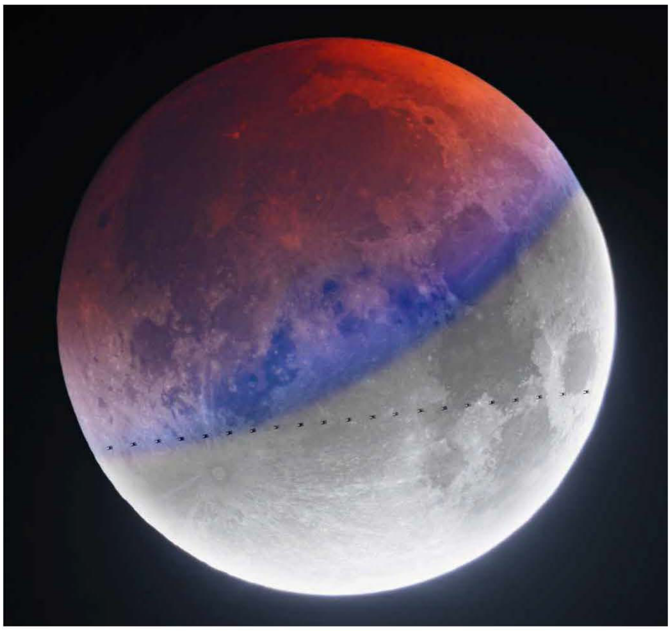
Equipment: ZWO ASI533MC Pro camera, Sky-Watcher Explorer 190MN reflector, Sky-Watcher EQ6-R Pro mount **Exposure:** 33h 25' total **Software:** PixInsight

▽ Five years of Saturn

Philip Michel, St Albans, Hertfordshire, UK, 28 August 2020–13 August 2025

Philip says: "I made this composite to show the evolution of Saturn's rings over the years – and how my imaging skills have improved."

Equipment: ZWO ASI290MC camera, Sky-Watcher Skyliner 300P Dobsonian **Exposure:** Best 33 per cent of 6,000 frames, 25ms per frame **Software:** AutoStakkert!, RegiStax

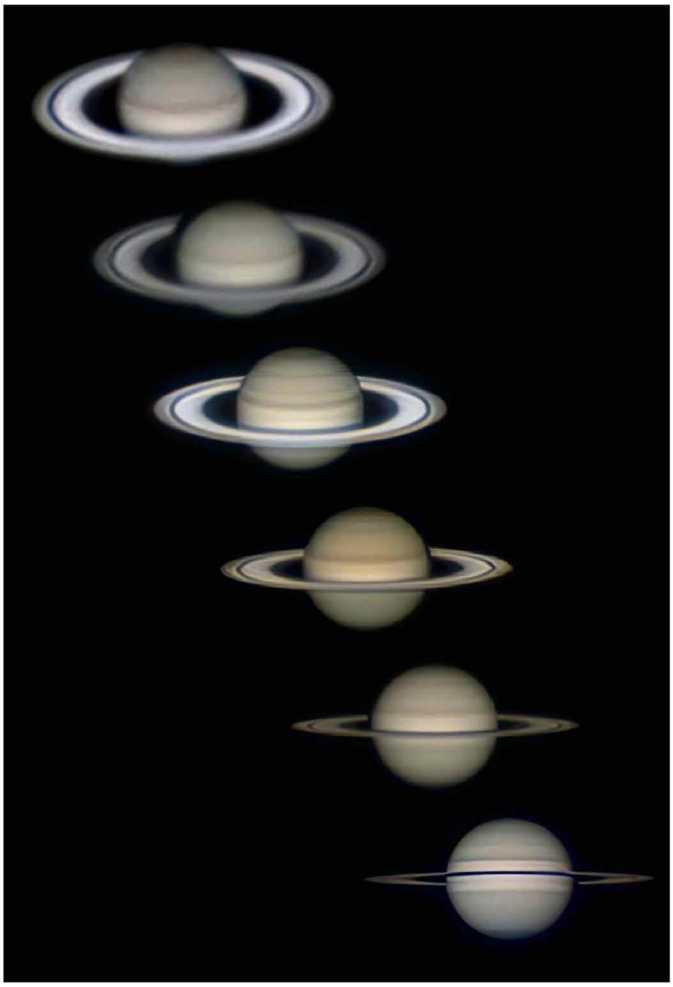


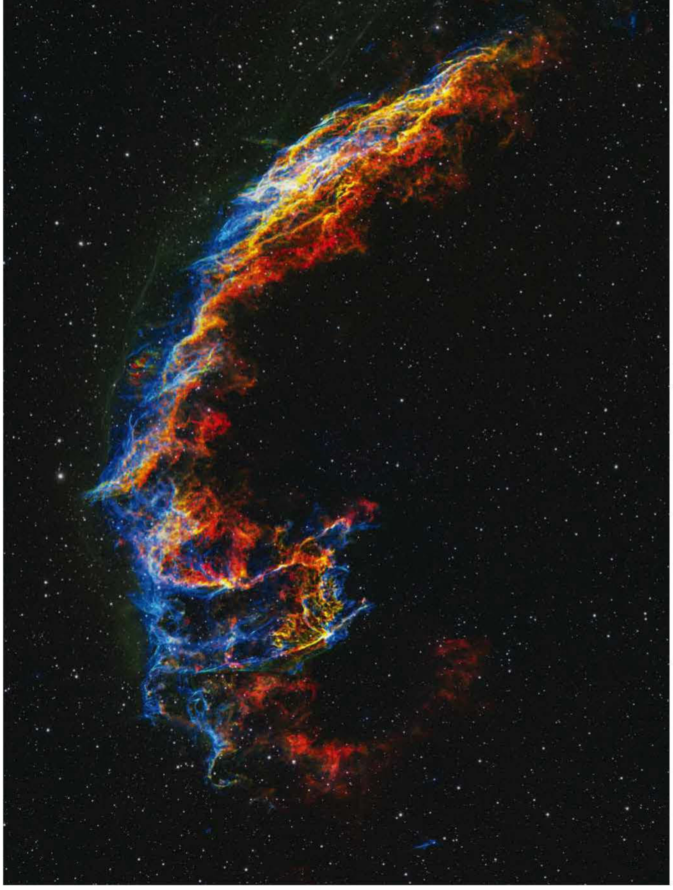
△ CSS lunar transit

Tianyao Yang, Chifeng, China, 8 September 2025

Tianyao says: "I don't believe anyone has captured Tiangong, the Chinese space station, transiting the Moon during a lunar eclipse before, so I was overjoyed to capture an event I'd been planning for since 2022!"

Equipment: Sony A1 camera, Sony 600mm lens, iOptron SkyTracker mount **Exposure:** transit ISO 1600 f/4, 22x 0.0005"; eclipse ISO 100 f/8, 0.5" **Software:** Lightroom, Photoshop, AutoStakkert!





◁ The Eastern Veil Nebula

Rachael and Jonathan Wood, Auckley, South Yorkshire, UK, 26 September 2025

Rachael and Jonathan say: "This was our first time capturing the Eastern Veil in an SHO palette. It's usually shared in red and blue, but we couldn't resist giving it a Hubble-style twist."

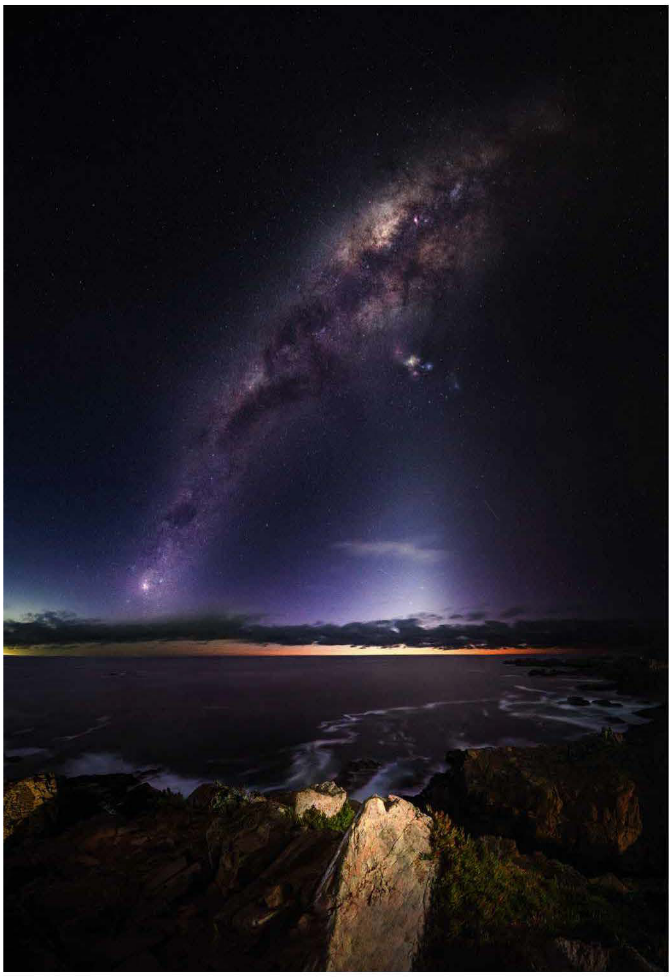
Equipment: ZWO ASI294MM Pro camera, Sky-Watcher Evostar 80ED refractor, Sky-Watcher AZ-EQ6 mount **Exposure:** SII 3h, Ha 3h, OIII 6h **Software:** Astro Pixel Processor, Photoshop

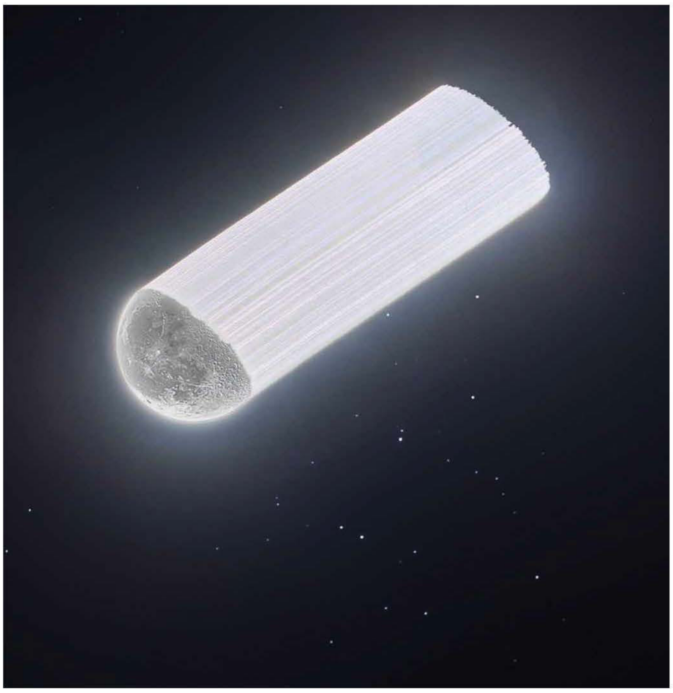
▽ Zodiacal Light

Tomas Andonie, Los Molles, Chile, 18 September 2025

Tomas says: "I was hoping to capture the newly discovered comet C/2025 R2 (SWAN), but instead I saw the Zodiacal Light – a beautiful surprise that I captured in this panoramic shot."

Equipment: Nikon D3300 camera, Nikkor 18–55mm and 55–300mm lenses, Sky-Watcher Star Adventurer 2i mount **Exposure:** ISO 3200 f/3.5, 131x 15" **Software:** Photoshop, Microsoft ICE, Siril





△ The Moon's orbit in starlight

Adeel Shafiq, Lahore, Pakistan, 13 September 2025

Adeel says: "This image traces the Moon's apparent sidereal motion as it passed the Pleiades. Capturing its journey in one continuous sequence was a rewarding experience."

Equipment: Canon EOS 1300D camera, Samyang 135mm lens, iOptron SkyTracker mount **Exposure:** ISO 100 f/6, 1,276x 3" **Software:** Photoshop

ENTER YOUR IMAGE

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miniCAM8
QHYCCD MONO NO.110191
ON A MISSION
The Smithson
History o
Women Astron
VALERIE NEA

86

Incredibly compact, surprisingly affordable and packing built-in filters to boot. Is the miniCAM8 really a mono marvel?

PLUS: the latest astro gadgets, gifts and books, including a history of women at NASA and a great read about black holes

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HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Our experts review the latest kit

FIRST LIGHT

QHY miniCAM8 monochrome camera bundle

Versatile, novice-friendly and well-priced – but loose connections let it down

WORDS: IVANA PERANIC

VITAL STATS

- **Price** £869
- **Sensor** Sony IMX585
- **Resolution** 8MP, 3,856 x 2,180
- **Exposure range** 11ms–900 seconds
- **Extras** Narrowband and LRGB filters, 12V power cable and adaptor, USB 3.0 cable, extension tube, screwdriver, filter mounting tweezer, camera bag
- **Size** 105mm x 102mm
- **Weight** 480g
- **Supplier** Rother Valley Optics
- **Tel** 01909 774521
- **www.**rothervalleyoptics.co.uk

QHY's miniCAM8 has got to be one of the most interesting recent releases on the astrophotography market: a petite, all-in-one imaging solution at an attractive price point.

QHY has added a dual-stage thermoelectric cooling fan to Sony's extremely popular IMX585 sensor, plus a suite of well-considered accessories, including an integrated eight-position filter wheel with complete LRGB and Ha, SII and OIII narrowband filter set, cables and adaptors. We anticipate this package could encourage newcomers to our wonderful hobby, as the filters make the camera suitable for a wide range of targets, including nebulae, galaxies and planets.

The bundle arrived in a compact box and included everything needed to dive straight into imaging. The customised set of seven filters comes in a separate blister pouch, which had to be carefully opened and filters inserted into the carousel using the provided tools, before sealing the camera housing. A video tutorial and pictorial guide are provided, but individual filter labels would make first-time setup far less confusing.

The camera itself is sturdy and surprisingly small (just over 10cm across) for a complete deep-sky imaging bundle. It's hard to believe that so many features can be packed into such a small unit, with the high-resolution sensor (plus dew control), electronic filter wheel and a cooling fan almost fitting into the palm of your hand.

Impressive filters

We followed the instructions and downloaded the QHY drivers, as well as SharpCap, which is included with the pack as a recommended capture software. When connecting the camera, both the power port and USB cable felt a little loose, with the latter losing connection if knocked. Still, we were able to test the camera out on the Dumbbell Nebula in LRGB with our Schmidt–Cassegrain telescope and were impressed to discover that the supplied custom-designed QHY filters were almost parfocal, with minimal difference in focus points when switching between filters.

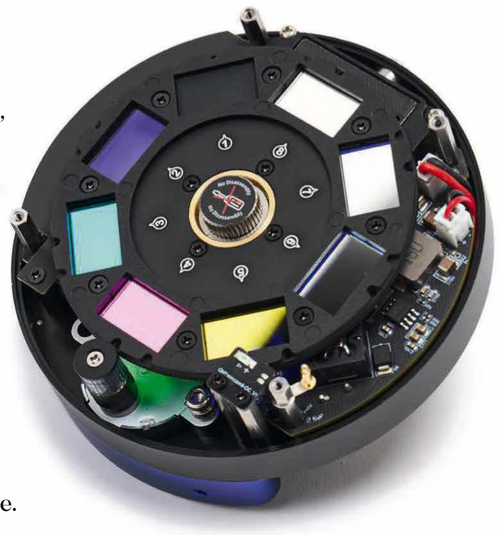
Despite taking just short exposures, we could see the nebula very clearly in the subs, highlighting the sensitivity of the IMX585 sensor. Once our LRGB ▶

Built-in filter wheel

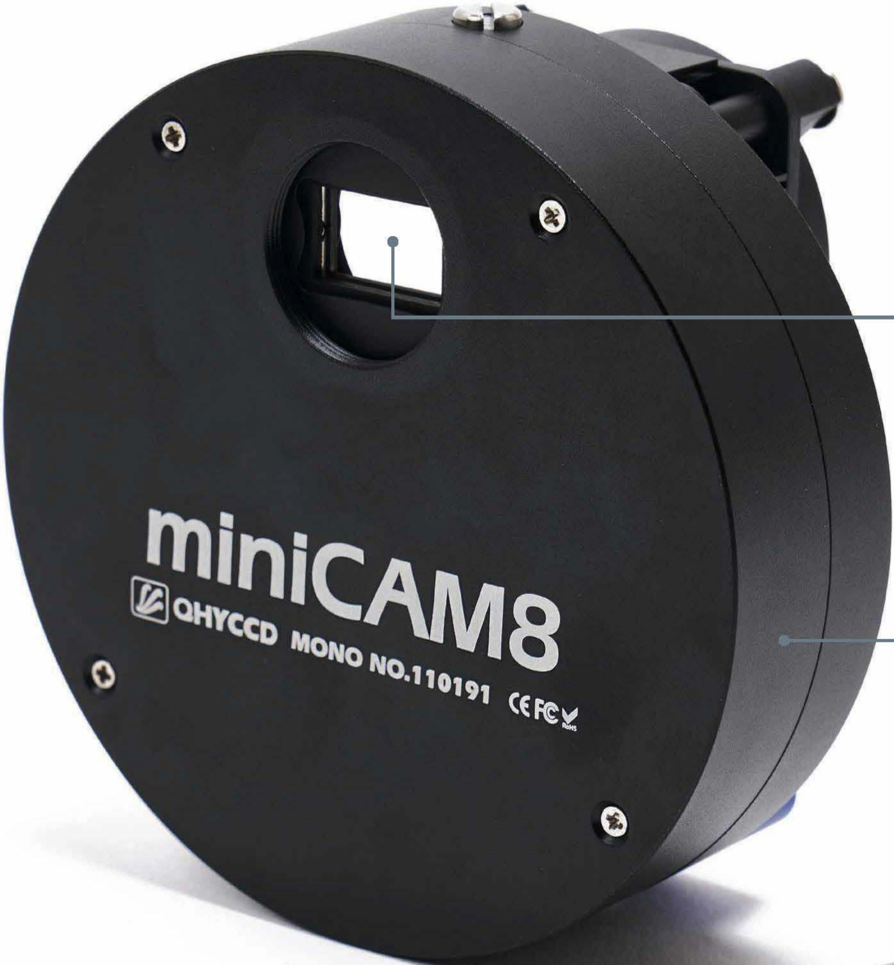
The miniCAM8 bundle includes an integrated filter carousel, so there's no need to purchase a separate wheel and filters – and the design stays impressively compact. The custom-cut filters are made specifically for the miniCAM8 – that saves space in comparison to standard 1.25-inch versions, but does mean they can't be swapped out for other brands. However, the bundle includes both LRGB and SHO sets to cover most monochrome imaging needs.

The eighth slot is filled with a 'dark filter' for easy calibration frame capture. The filters aren't marketed as parfocal, but we saw no significant focus shifts between them, and it would certainly be short work for most automatic focusers.

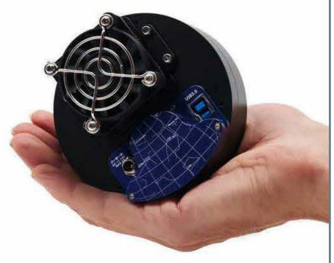
The camera's compact design means that the filters sit very close to the sensor, which helps eliminate vignetting. For the price, the variety of filters included in the package and its overall performance are remarkable.



ALL PICTURES: @THESHED_PHOTOSTUDIO



SCALE



Mono sensor

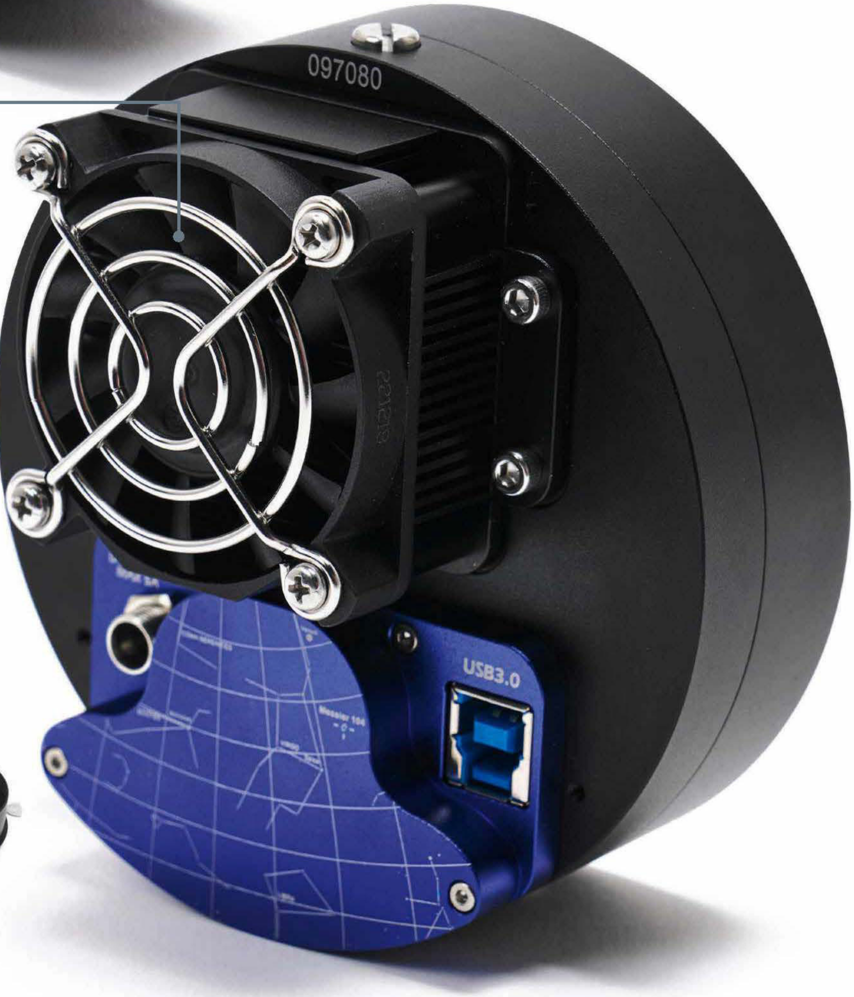
The heart of the camera is Sony's latest IMX585 STARVIS 2 monochrome sensor with high sensitivity, especially in the infrared and near-infrared range. The 11.18mm x 6.32mm sensor is capable of HDR (high dynamic range) and low noise, and its back-illuminated technology promises zero amp glow, which we were able to verify in test subs.

Compact design

One of the most attractive features of the miniCAM8 is its size and integrated design. Those wanting to try mono imaging on a budget don't have to buy and assemble their own filter wheels and filter sets – they're all here in a simple, compact all-in-one package. The weight of the whole unit is also impressive, making it a much lighter imaging setup than one assembled from separate components.

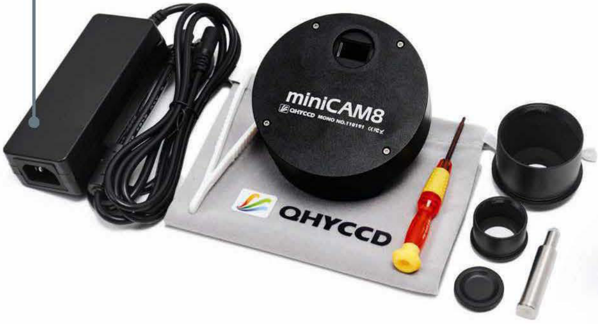
Dual-stage cooling

At the back of this already miniature unit is another fantastic design feature: a small but powerful fully integrated dual-stage fan, capable of cooling to –45°C. It's slightly noisier than we expected and turns on automatically as soon as the camera draws power from the 12V port.

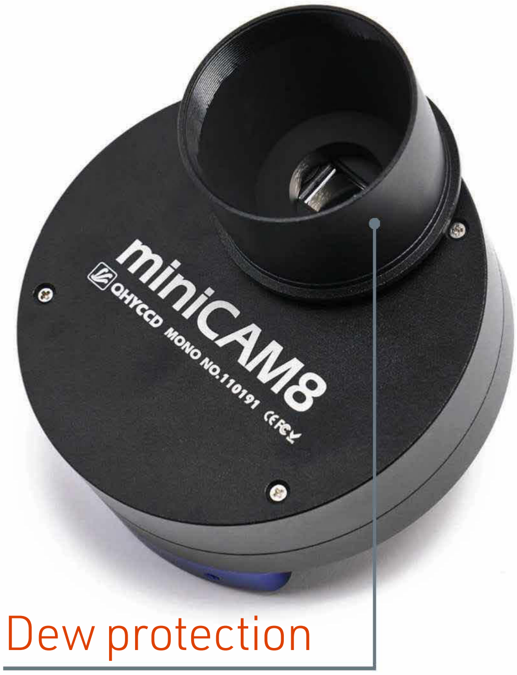


Plenty of accessories

Despite its small size and affordable price, the miniCAM8 bundle contains everything you need to get imaging. We were pleased to see all relevant power and USB cables included, as well as a 1.25-inch nosepiece and M48 adaptor, tools for assembling the filter wheel and even a small storage bag.

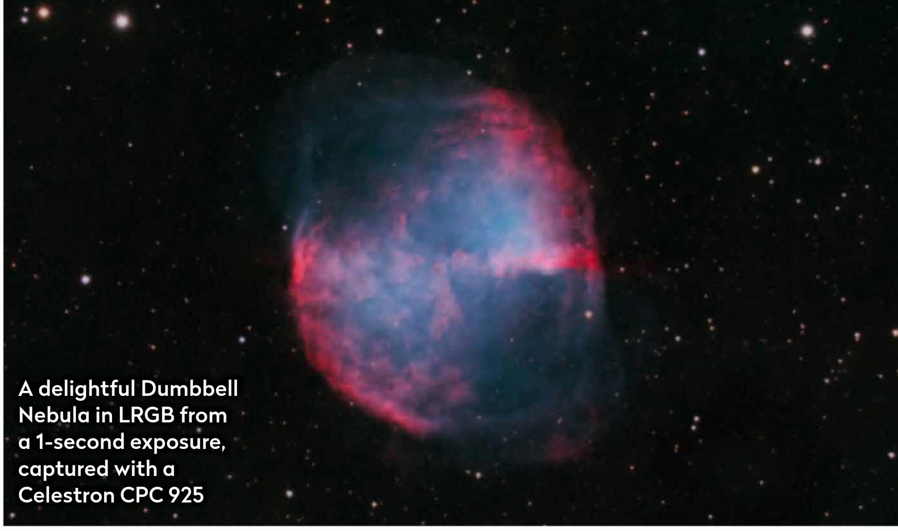


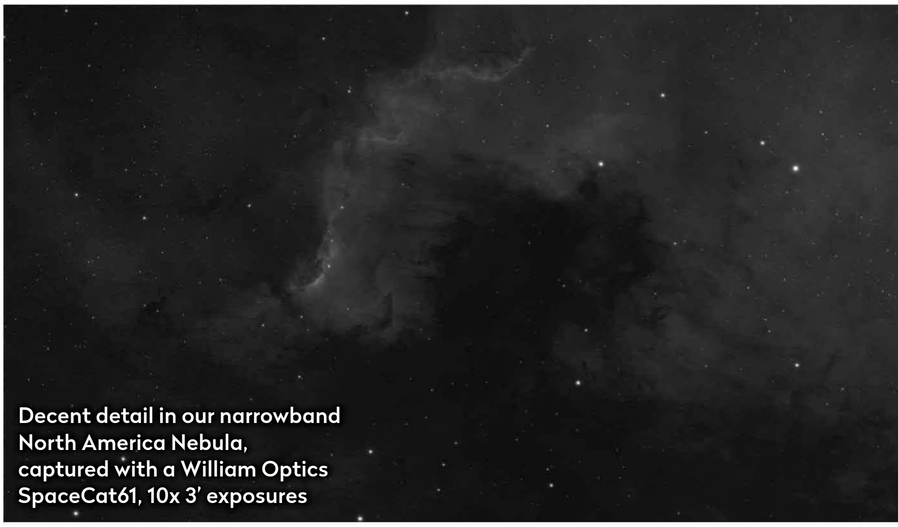
FIRST LIGHT

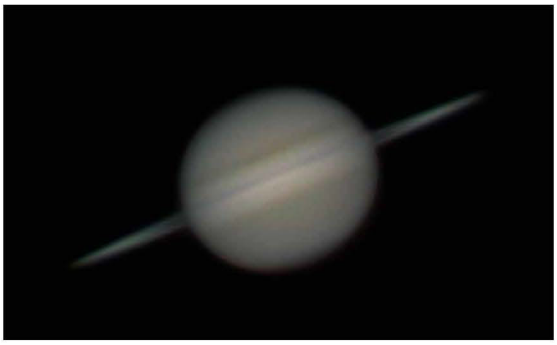


Dew protection

The housing may be miniature, but QHY has managed to include a dew heater on the optic window to help stop condensation, plus a silica gel tube socket to protect the sensor chamber (you need to add your own silica desiccant to the socket and attach it to the port above the sensor).


A delightful Dumbbell Nebula in LRGB from a 1-second exposure, captured with a Celestron CPC 925


Decent detail in our narrowband North America Nebula, captured with a William Optics SpaceCat61, 10x 3' exposures


◀ While the miniCAM8 is no match for dedicated planetary cameras, we were happy with our edge-on Saturn

▶ frames were combined in post-processing, the filters generated a beautiful result and lovely colour balance in the stars.

Disconnection issues

In our second imaging session, we turned to the North America Nebula with a 61mm refractor, to test the provided narrowband filters. While capturing test images, we were happy with the level of detail and minimal focus adjustment between the filters. However, there was a sharp line across the subs.

After checking the power cable, we noticed it had slipped under its own weight while the camera was pointing at zenith. This had resulted in the camera disconnecting from SharpCap. As we readjusted the USB 3.0 cable, it discharged and caused an electrical short on our laptop. The laptop was undamaged and the supplier swiftly sent us a replacement miniCAM8. The power port on the replacement unit was snugger; that said, the connection remained loose and warrants further attention from QHY.

With a few short hours of clear skies ahead, we turned to Saturn for a planetary imaging test. The miniCAM8 is capable of the sub-second exposures needed for planets and the filters again performed well – though the QHY drivers were a little sluggish when changing between them or choosing between regions of interest. If you're hoping to capture planets just as well as deep-sky objects, you may be disappointed with the low frame rate compared to dedicated planetary cameras. Still, we were pleased with our results, especially Saturn's edge-on rings.

Overall, the QHY miniCAM8 monochome camera bundle is a brilliant concept offered at a truly fantastic price point, that's sadly let down by QHY's quality control. Even so, we can see it satisfying a range of different imaging interests, from a simple and effective entry into monochrome imaging to a useful, compact travel camera.

KIT TO ADD

1. QHY off-axis guider for miniCAM8

2. Weather station

3. Processing software

VERDICT

Build & design	★★★★☆
Connectivity	★★☆☆☆
Ease of use	★★★☆☆
Features	★★★★☆
Imaging quality	★★★★☆
OVERALL	★★★☆☆

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Our experts review the latest kit

FIRST LIGHT

Sky-Watcher StarQuest DX130P Newtonian reflector set

A quality set for beginners, delivering heaps of value for the price

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £279
- **Optics** 130mm parabolic Newtonian
- **Focal length** 650mm, f/5
- **Focuser** 1.25-inch rack and pinion
- **Mount** German equatorial
- **Extras** 20mm and 10mm eyepieces, red dot finder, smartphone adaptor, accessory tray, screwdriver
- **Weight** 11.4kg
- **Supplier** Optical Vision Limited
- **Tel** 01359 244200
- **www.** opticalvision.co.uk

Any beginner telescope kit should be easy to use and come complete, with no need for extra purchases. Sky-Watcher's latest addition to its StarQuest line, the DX130P, offers new astronomers exactly that: a novice-friendly all-in-one solution that turned out to be a genuine pleasure to review.

Unpacking the boxes, we discovered a smart metallic black optical tube assembly, tubular steel tripod with accessory tray, Sky-Watcher's new StarQuest DX equatorial mount with counterweight and bar, and a box of accessories that included a red dot finder, two eyepieces, a smartphone adaptor kit and a crosshead screwdriver.

Also included in the package were comprehensive illustrated instructions that show you how to set up the mount and balance the telescope. However, these could bear a little copy-editing; there were several typos, descriptions of the red dot finder that segued between an older version and this newer one, mislabelled components in diagrams, and polar alignment instructions that could leave users looking for crosshairs in the red dot finder.

Nevertheless, our immediate impression was how simple the set-up process was, and how tidy and robust the DX mount is compared to other equatorial mounts aimed at beginners.

The white enamel finish with green altitude, right ascension and declination scales gives it a clean appearance and, of course, the scales look almost black under an astronomer's red-light torch. The altitude adjustment scale is marked at intervals of 3°, which is adequate to set it for visual observation. Altitude is adjusted by a T-bolt that bears against a tongue attached to the head; the adjustment range is 0° to 66°.

Wide, bright views

Sky-Watcher describes the 10mm (65x) and 20mm (32.5x) eyepieces as 'photo/visual'. We examined them and found that they're a reverse Kellner design (in simple terms, this swaps the usual lens positions to give beginners a wider view than older eyepiece types), which was reinforced when we measured their apparent field of view to be 52°. As spectacles wearers, we soon discovered that neither eyepiece ▶

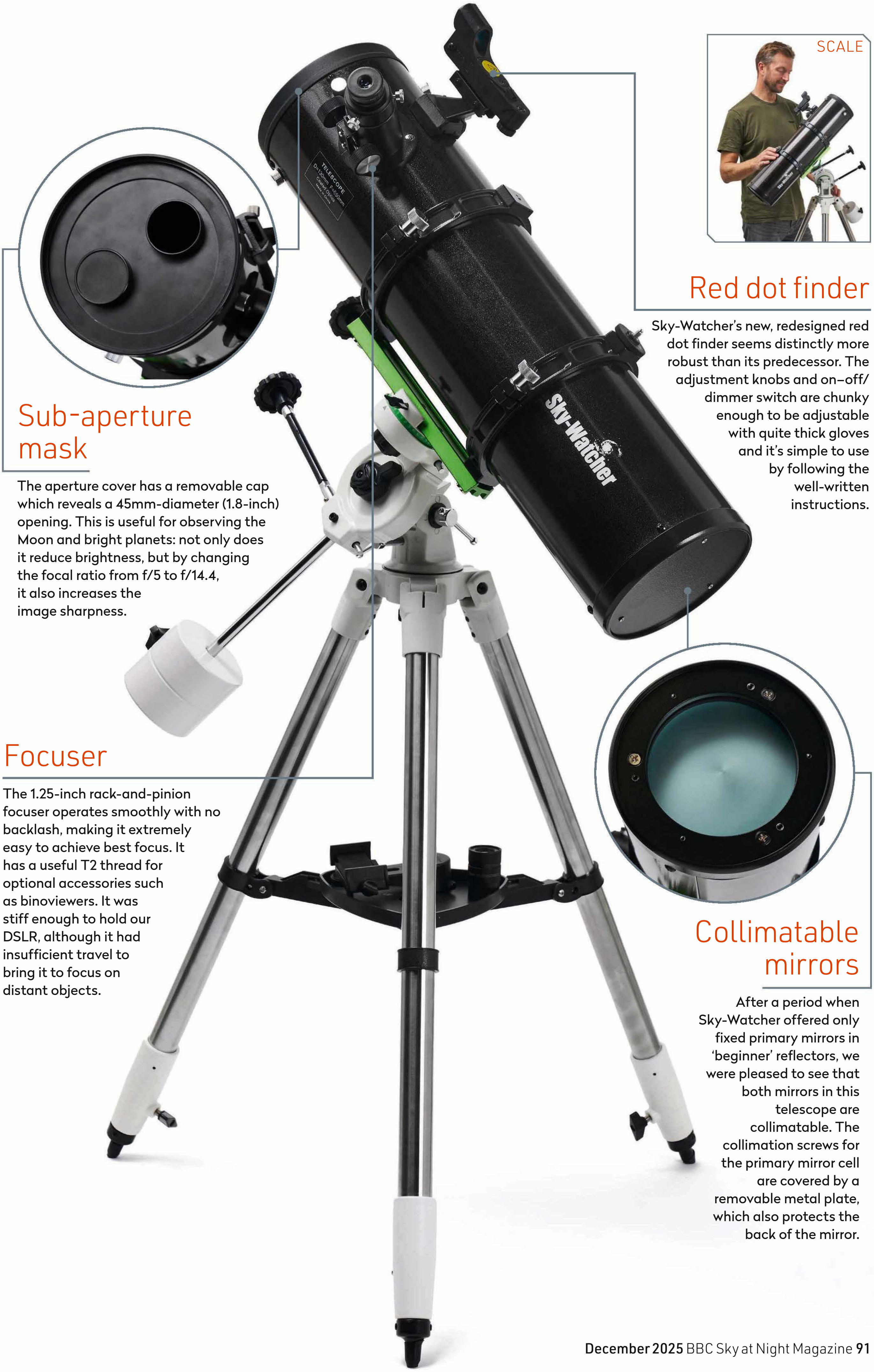
Beginner's mount, pro feel

Astronomical instruments simply can't perform well without a stable base and a robust head that moves smoothly. Ones for beginners need to be easy to use too. We were delighted to find that the new StarQuest DX mount ticks all these boxes.

We found it intuitive to assemble, but if you're less confident, the manual offers clear, illustrated instructions for assembly and use. We recommend practising in daylight first; after that, you'll find it easy to set it up under a dark sky.

The large clutch knobs on the right ascension and declination axes are easy to operate, even with gloves on. The flexible slow-motion knobs turn the axes smoothly with almost no backlash or vibrations. They're secured with short crosshead screws (screwdriver included), which are less prone to snagging on things and working loose than the more common long thumb screws.

ALL PICTURES: @THESHED_PHOTOSTUDIO



Red dot finder

Sky-Watcher's new, redesigned red dot finder seems distinctly more robust than its predecessor. The adjustment knobs and on–off/dimmer switch are chunky enough to be adjustable with quite thick gloves and it's simple to use by following the well-written instructions.

Sub-aperture mask

The aperture cover has a removable cap which reveals a 45mm-diameter (1.8-inch) opening. This is useful for observing the Moon and bright planets: not only does it reduce brightness, but by changing the focal ratio from f/5 to f/14.4, it also increases the image sharpness.

Focuser

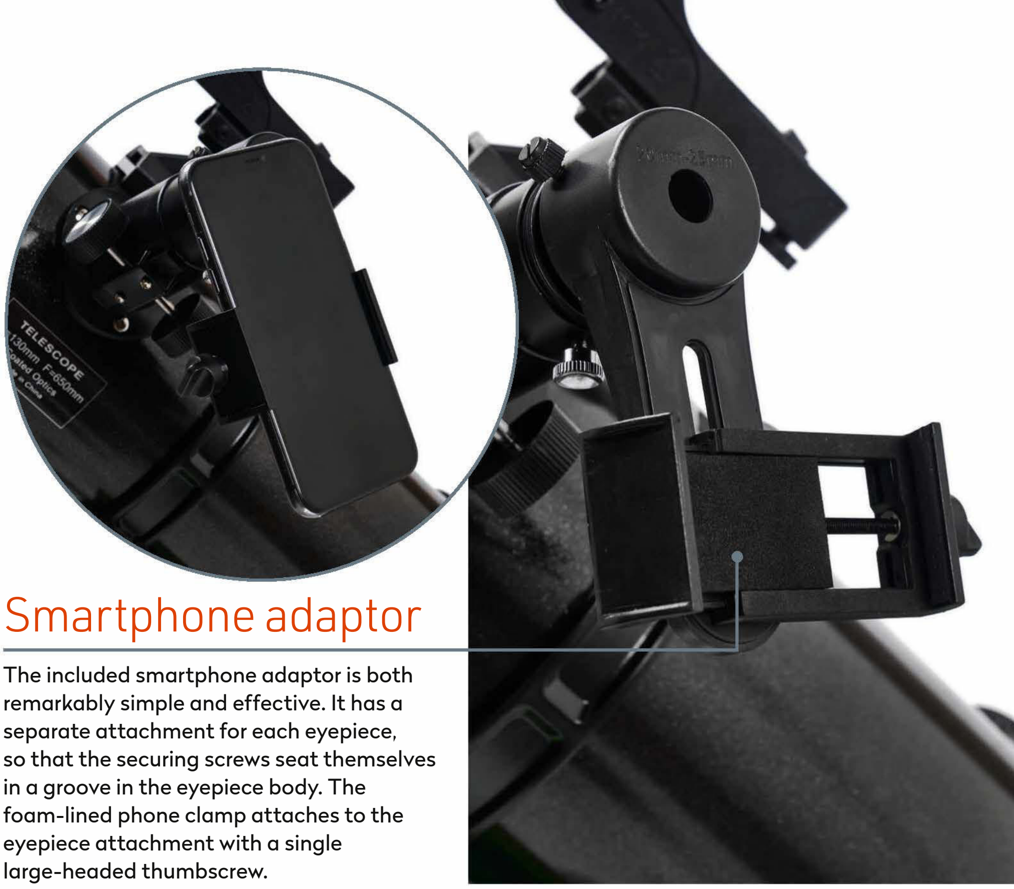
The 1.25-inch rack-and-pinion focuser operates smoothly with no backlash, making it extremely easy to achieve best focus. It has a useful T2 thread for optional accessories such as binoviewers. It was stiff enough to hold our DSLR, although it had insufficient travel to bring it to focus on distant objects.

Collimatable mirrors

After a period when Sky-Watcher offered only fixed primary mirrors in 'beginner' reflectors, we were pleased to see that both mirrors in this telescope are collimatable. The collimation screws for the primary mirror cell are covered by a removable metal plate, which also protects the back of the mirror.

FIRST LIGHT

Double star Albireo captured with our Xiaomi Poco X3 mounted on the included smartphone adaptor



Smartphone adaptor

The included smartphone adaptor is both remarkably simple and effective. It has a separate attachment for each eyepiece, so that the securing screws seat themselves in a groove in the eyepiece body. The foam-lined phone clamp attaches to the eyepiece attachment with a single large-headed thumbscrew.

The useful aperture mask helped cut Moon glare

▶ had enough eye relief to enable us to see the entire field of view with spectacles on.

We checked collimation and found that it needed some attention, which took just a few minutes with our laser collimator. If you don't have such a device, the manual does provide very comprehensive instructions on how to collimate without one. A star test indicated that the optics were free of image-degrading spherical aberration.

Excellent for clusters

The eyepieces give reasonably sharp images almost to the edge of the field of view and have good colour rendition. They don't have anti-reflective coatings but, with only four glass-to-air surfaces, the image was suitably bright. We didn't detect any internal reflections, and the image quality was only very marginally improved when we substituted one of our own high-quality orthoscopic eyepieces.

We spent several happy hours revisiting old friends in the summer Milky Way and, later, Taurus and Auriga. Saturn and Jupiter were far too bright, unless we used the included sub-aperture mask. The telescope excelled on medium-sized open clusters, including the Owl Cluster, NGC 457. We were well into the observing session before we realised the lack of vibrations when using the slow-motion controls – excellent!

The phone adaptor was simple to use, but unless your camera shutter can be voice-operated, you'll want to get a Bluetooth remote control for it to avoid shake. If you're new to equatorially mounted Newtonians, you'll need to get used to rotating the optical tube in its rings when you change from observing objects east of the mount to those west of the mount. This is best done with the tube horizontal so it doesn't slip out of balance; you may wish to mark the balance point with a piece of tape on the tube, to make repositioning quicker and easier.

Overall, the Sky-Watcher StarQuest DX130P is a thoughtfully designed and impressively executed telescope that was an absolute joy to use. We'd have been delighted to have had one of these when we were starting out in the hobby. If you're in that position, this could well be the scope for you.

Sky-Watcher

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VERDICT

Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Assembly	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. Sky-Watcher 1.25 ND Moon filter

2. Sky-Watcher 8mm–24mm zoom eyepiece

3. Collimator

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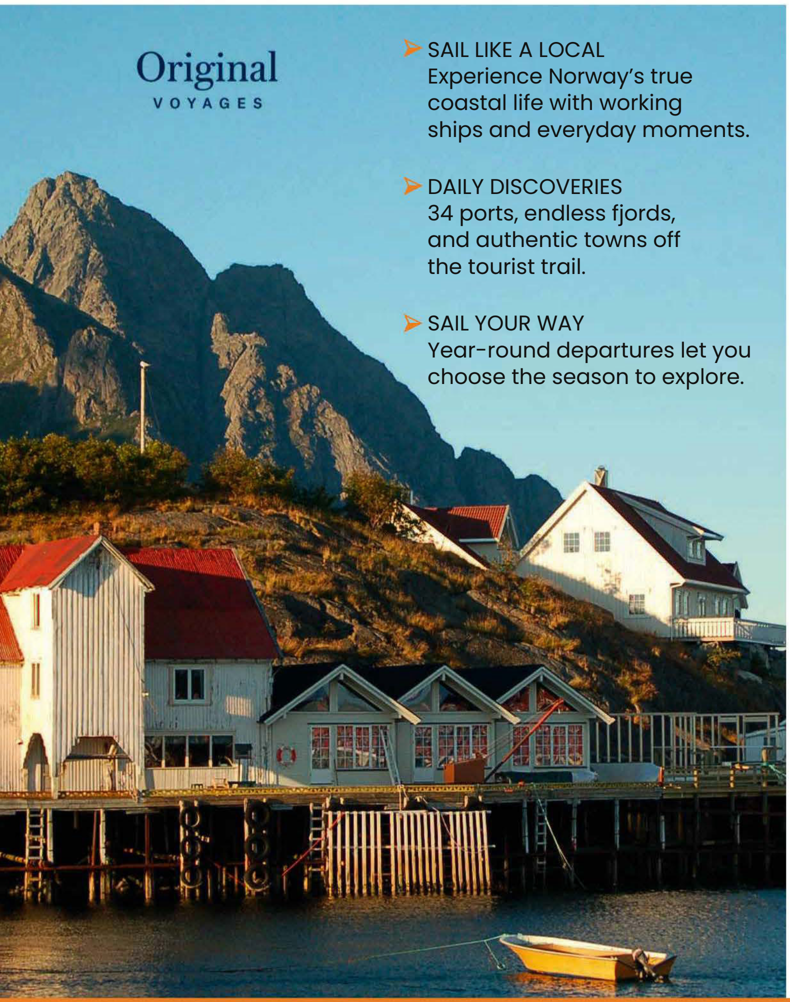

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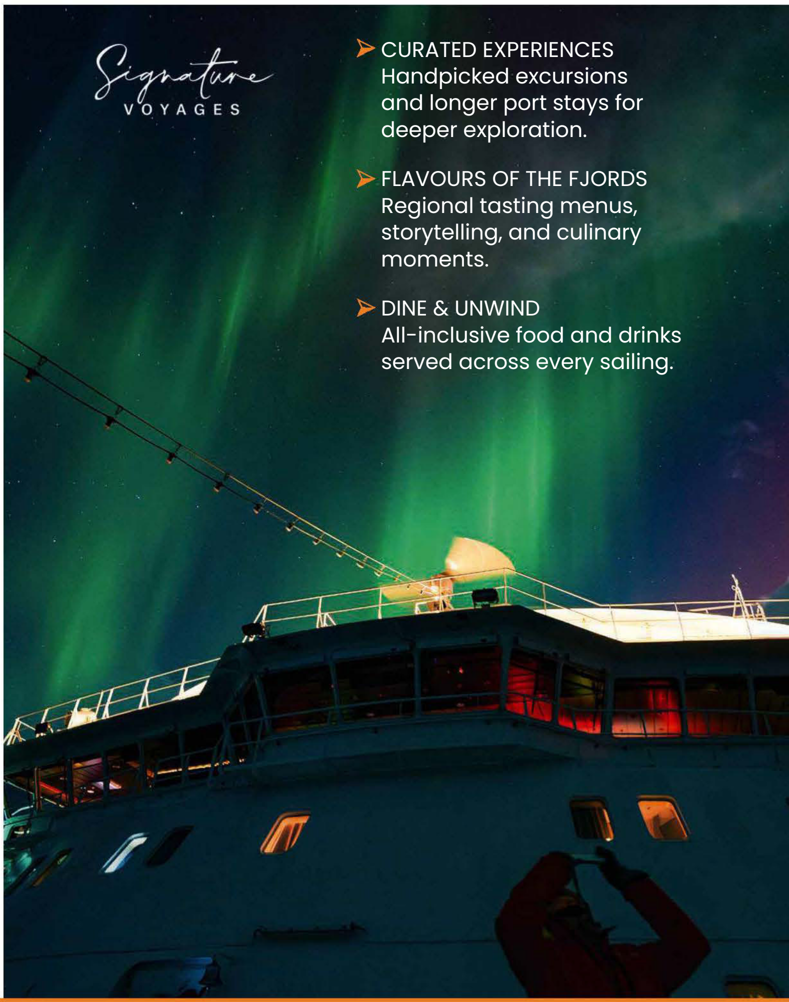

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Menu

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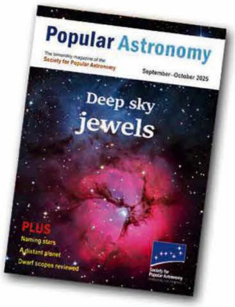

Popular Astronomy
September–October 2025
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PLUS
Naming stars
A distant planet
Dwarf scopes reviewed

The Society for Popular Astronomy requires an editor for *Popular Astronomy* magazine. This is a unique opportunity for anyone interested in a career in science journalism and outreach.

We need someone with a good knowledge of both professional and amateur astronomy, excellent writing skill, an eye for detail and an ability to meet bi-monthly deadlines. Remuneration (not astronomical!) to be discussed.

If you are interested please contact Robin Scagell at editor@popastro.com by 30 November 2025 with details of your background and any editorial experience. Please include an appropriate example of your original writing.

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Charlotte Daniels rounds up the latest astronomical accessories

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1

2

Eye relief:20mm F.O.V:62°–40°
BRESSER
3

AIRFIX
1:144 SLS ARTEMIS
MODEL KIT
4

5

6

1 Omegon red dot finder for DSLR

Price £60 • **Supplier** The Widescreen Centre
www.widescreen-centre.co.uk

DSLR cameras coupled with long lenses are a great route into astrophotography. This LED finder, with five brightness levels, fits into a DSLR's hot shoe bracket and simplifies the process of finding your targets.

2 Planets sweatshirt

Price £44.95 • **Supplier** VO Clothing
www.vo.clothing

This unisex sweatshirt is perfect for all astronomers. Made from combed and ringspun cotton, it's manufactured using eco-friendly methods and arrives in plastic-free packaging. Available in navy, green or black, it comes in sizes XS to 2XL.

3 Bresser LER zoom 1.25-inch deluxe 8mm–24mm eyepiece

Price £225 • **Supplier** Bresser UK
www.harrisontelescopes.co.uk

We love a zoom eyepiece for grab-and-go astronomy! This version features multi-coated lenses and is made from black anodised aluminium. With a large apparent field of view between 40° and 62°, the 20mm eye relief should ensure it's suitable for spectacle wearers too.

4 Airfix Artemis gift set

Price £49.99 • **Supplier** Airfix
https://uk.airfix.com

This version of the classic Airfix kit arrives in 79 pieces and, once assembled, is a 1:144 scale model of NASA's launch system and vehicle, the SLS Artemis. If you're new to model building, this set has everything you need to get started, including paints, poly cement, decals and instructions.

5 Habitat moons and stars stocking

Price £12 • **Supplier** Argos • **www.argos.co.uk**

We thought this charming Christmas stocking would be perfect for housing small festive astronomical accessories, from eyepieces to filters. It features gold embroidered celestial objects, nestled on navy velvet. You can also buy a Christmas sack version, for surprise telescopes and mounts!

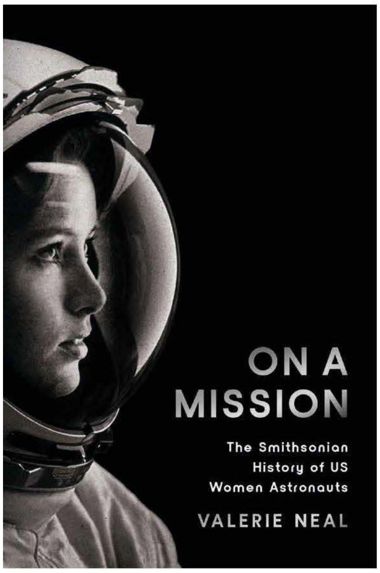
6 StellaLyra binoviewer

Price £329 • **Supplier** First Light Optics
www.firstlightoptics.com

This linear erect binoviewer provides images the right way up when used without a diagonal, so can also be used for daytime or terrestrial views. Its parfocal design works on almost all telescope types without a Barlow, ensuring you can reach focus with your 1.25-inch eyepieces.

New astronomy and space titles reviewed

BOOKS



On a Mission

Valerie Neal
Smithsonian Books
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This is an inspiring tribute to the trailblazing women who shaped NASA's human spaceflight programmes. Meticulously researched and thoughtfully written, it charts the evolution of their roles in space exploration, offering both historical insight and personal stories that bring these pioneers to life.

From behind-the-scenes brilliance to spaceflight milestones, Neal celebrates women at NASA

NASA

Neal sets the stage with a look at the cultural and institutional barriers women faced in entering aviation and spaceflight, highlighting the misconceptions about the female body and psyche that long kept women from consideration. Chapter two introduces us to the 'firsts' – those who broke barriers and redefined what was possible. Here we meet Sally Ride, the first American woman in space; Kathy Sullivan, the first American woman to perform a spacewalk; Mae Jemison (pictured), the first Black American woman in space; and Eileen Collins, the first woman to command a Shuttle mission. Subsequent chapters spotlight the astronauts who became icons in their own right, such as Kalpana Chawla, Cady Coleman and Peggy Whitson, as well as those carrying the torch forward, such as Nicole Mann, the first Native American woman in space, and Christina Koch, who will be the first woman to fly to the Moon, as part of the upcoming Artemis II mission.

I really appreciated the inclusion of concise yet detailed biographies for every American woman who has served – and still serves – as an astronaut. These are written in an accessible and deeply engaging way that vividly captures each one. Particularly compelling are the sections that explore how women contribute behind the scenes – in mission control, astronaut training and as public ambassadors for NASA – and the exploration of the human side of spaceflight, tackling important topics like gynecology in space, ill-fitting EVA suits and the challenges of balancing career and family life.

On a Mission is a celebration of those who paved the way and those taking that mantle forward. With NASA's announcement of a new astronaut class – where, for the first time, women outnumber men – it couldn't be timelier. A must-read for human spaceflight enthusiasts and anyone inspired by stories of perseverance and progress.
★★★★★

***Melissa Brobby** is a science communicator and astronomy writer*

Interview with the author
Valerie Neal

You're a Smithsonian curator. What does that involve?

My role spans scholarship – doing historical research, writing articles and books, managing the national collection of historic artefacts, developing exhibits, and public engagement through lectures, documentaries, tours and special programmes.

Who are the trailblazing women of spaceflight?

They're all trailblazers, each forging her own path to cross the highest hurdles and fly in space. The first six Americans – Sally Ride, Judy Resnik, Kathy Sullivan, Anna Fisher, Rhea Seddon and Shannon Lucid – and their successors proved women belonged in space. Then Mae Jemison and Ellen Ochoa broke barriers of race and ethnicity. The first military pilots to become astronauts – Eileen Collins, Nancy Currie and Susan Helms – topped the last barrier. Today, Christina Koch will soon be the first woman to orbit the Moon, and after her will be the first woman to land on the Moon.

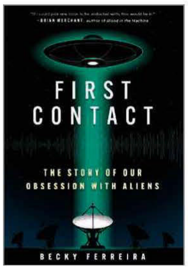
Are you excited about Artemis?

Having witnessed Apollo, I'm excited to see the USA return to the Moon and prepare for a sustained lunar presence. If NASA keeps its pledge to land the first woman and first African-American on the Moon, it will signal that anyone can aspire to be a space explorer. Maybe a future curator will collect objects representing these achievements and see this era as an inflection point, when humanity embraced – or rejected – living beyond Earth.

***Valerie Neal** is an emerita curator of space history at Smithsonian's National Air and Space Museum*

First Contact: The Story of Our Obsession with Aliens

Becky Ferreira
Workman Publishing
£22 ● HB



From mythology to hard science and everything in between, *First Contact* is a lively, wide-ranging exploration of almost any topic you could think of related to aliens. Abductions? Check. Exoplanets? Check. Even exodinosaurs? Check!

Across brief chapters interspersed with quotes, fun facts, definitions, illustrations and stories, Ferreira explores where aliens might be, how we might find them, what happens if we do, and why humanity has always been so obsessed with the idea of extraterrestrial visitors. There's also thoughtful discussion on the ethics of space exploration and the potential for human interference in alien ecosystems. For example, the experiments used by NASA's Mars Viking landers to search for signatures of life had, ironically, a 50/50 chance of killing any microbes that were found. Are humans comfortable with a loss of potentially unique alien lifeforms, in order to discover them?

One question the book returns to time and again is, if there are aliens are out there, what might they think of us? Are we puny weaklings to be destroyed, dangerous idiots to be avoided, or could we even become interplanetary allies, with the knowledge that we aren't alone in the Universe giving us a fresh perspective on our own home planet?

Despite being dense with facts and pop-culture references, *First Contact* is always fun, digestible and accessible. Sections on the history of aliens and alien-related folk tales are fascinating and unusual, including bizarre and beautiful historical artwork and illustration. This is primarily a quick and easy read rather than an astronomical textbook, but the science is sound, making a perfect introduction to the key aspects of star systems and star types. Impressively, Ferreira's voice and humour is clear even when discussing the drier technical details of the search for exoplanets.

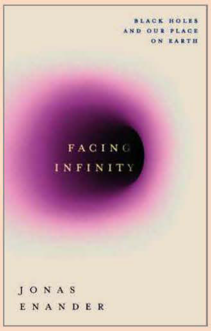
While the writing is deliberately concise, a few sections stray into feeling slightly cut short. In longer chapters, the consistent cut-aways to asides, definitions and short stories can make the pages feel a little busy, making it hard to follow the thread without jumping back and forth. However, this is an impressively comprehensive book, perfectly designed for the alien obsessive. Ferreira concludes: "I love aliens. I hope I've made that clear." I'd say mission accomplished! ★★★★☆

***Katie Sawers** is a science writer and associate editor at IOP Publishing*

Facing Infinity

BLACK HOLES

Jonas Enander
Atlantic Books
£18.99 ● HB



What would happen to you if you fell into a black hole? Could you survive? What would you find on the other side of the event horizon? These and many other questions are answered (to the best of our scientific knowledge) in *Facing Infinity*. But, don't be fooled: this isn't a sensational Hollywood-style tale of mysterious, ubiquitous monsters. It is, in fact, one of the most detailed and accessible accounts of black holes to appear in recent years.

The author has taken great pains to include the human story behind our discovery of black holes. Naturally, it covers historical figures like John Michell, Albert Einstein and Stephen Hawking, but Enander has also travelled the world talking to recent or current players on the frontiers of black hole research. These contributors, including leading figures such as Roy Kerr, Shep Doeleman and Kip Thorne, add a fascinating depth to the narrative, and place us directly in the unfolding story.

Another theme that pulls this book out of the mainstream is the exploration of how black holes relate directly to humans. Precise timekeeping using distant black holes (within quasars) has allowed scientists a better appreciation of climate change and plate tectonics. Furthermore, we're just beginning to realise that black holes may be responsible for the creation and distribution of many of the elements that make life possible. Black holes may also be killers – these gargantuan feeding machines may have been responsible for mass extinction events on Earth, due to the copious amounts of gamma rays they produce.

A most welcome section concerns the difficult issue of geopolitical tensions stirred up by astronomers siting their instruments on native (or otherwise sensitive) land. The problem was recently demonstrated by Native Hawaiians raising objections to the expansion of operations (namely the building of the Thirty Meter Telescope) on Mauna Kea, a place of cultural and spiritual importance. Enander zooms out of this unease (and several other instances) to frame these disputes as a consequence of colonialism. Although offering no solutions beyond compassion and consideration, this is a long-overdue discussion.

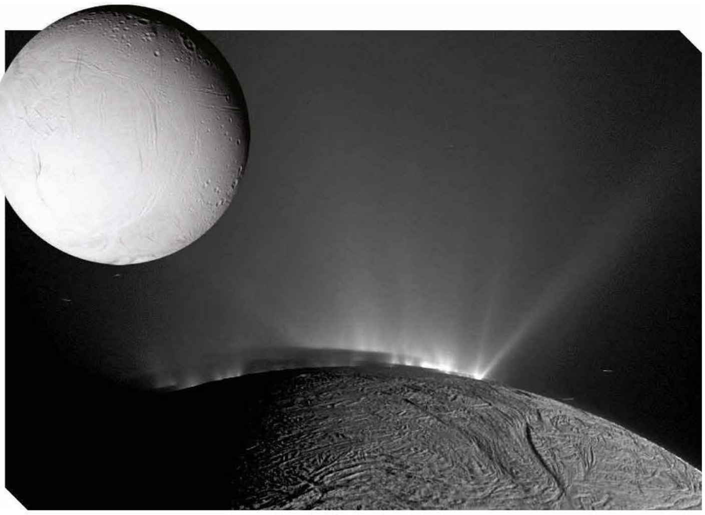
This book is highly recommended to anyone fascinated by gravitational behemoths in all their guises. ★★★★★

***Alastair Gunn** is a radio astronomer and science writer*

Anita Chandran talks to Dr Nozair Khawaja

Q&A WITH A PLANETARY LIFE EXPERT

Saturn's icy moon Enceladus boasts water, heat and organics. Now scientists have discovered it has complex chemistry too. Could it prove to be habitable?



▲ **Plumes burst from Enceladus's south pole. Studies of freshly ejected ice grains now show chemical reactions are thriving in the moon's ocean**

What is Enceladus?

Enceladus is a medium-sized moon of Saturn made up of a crust of water-ice and an ocean of liquid water below. This ocean is in some senses similar to those on Earth and is connected directly to Enceladus's rocky core. Water from Enceladus's ocean is emitted in large jets through cracks in the icy crust near the moon's south pole.

What causes these jets?

They happen because Enceladus is orbiting a much larger body: Saturn. Saturn's gravitational pull causes Enceladus to stretch, compress and relax, which gives rise to an immense amount of friction.

This friction is converted into heat, which causes interactions between the water and rock and hydrothermal vents at the bottom of Enceladus's ocean. These vents in turn push material to the top of the ocean, where it bursts through the cracks as plumes of water vapour and ice grains. These plumes can be enormous, reaching thousands of kilometres above the moon's surface.

Why are scientists interested in Enceladus?

We're searching for habitable places beyond Earth, places where there's evidence of past life or the possibility of future life. We think that for a place to be habitable, it should meet three 'green lights' – and Enceladus meets them all.

The first green light is liquid water must be present. Secondly, an energy source is needed, which we think could be tidal heating. Lastly, you need the right set of elements to form, support or sustain life: carbon, hydrogen, nitrogen, oxygen, phosphorus and maybe sulphur, as well as organic molecules. We have detected all of these elements on Enceladus.

What did your team discover?

We found new, complex organic compounds in ice grains in Enceladus's plumes. To understand the significance of the discovery, we must look back at the Cassini space mission, which was in the Saturnian system from 2004 to 2017. During its lifetime, Cassini collected measurements from lots of ice particles from Enceladus's plumes and from the rings of Saturn. Previously, we used that data to look at older ice particles sitting in Saturn's E ring, the second-outermost of its rings. We knew these had been ejected from Enceladus's subsurface oceans, but that while they sat in the E ring (for months and years), they might have been changed by the effects of radiation.

Our new research looked at ice grains collected by Cassini just minutes after they were ejected from Enceladus. We found two interesting things: the same organic compounds in both samples, meaning that those complex compounds in the E ring had the same origin – Enceladus's subsurface ocean; and new organic compounds that had never been seen before in ice grains ejected from Enceladus. The bigger picture is that these organic molecules must also originate from Enceladus's ocean and they provide a complex picture of Enceladus's subsurface chemistry.

What does that mean for the potential for life on Enceladus?

What we can say is that all three major keystones for life exist on Enceladus, which makes it a potential candidate for a habitable environment. I would go a step further and say that, even if we don't discover any life there, better investigations of Enceladus will tell us something about what life might need. For example, we will be in a better place to answer the question: if we have water, heat and organics, why isn't there life? What are we missing?

What's next for your team?

We're continuously exploring data from Cassini to understand more about Enceladus. Enceladus is also the target for future missions; knowing what the payload of these missions should be – what instruments should be on board, what we might like to investigate – is also a target of our research. There are also missions (NASA's Europa Clipper and ESA's Juice) to Jupiter's moon Europa, another candidate for exploring habitability, currently under way. So, there's a lot to look forward to.

Nozair Khawaja is a planetary scientist based at Freie Universität in Berlin exploring the habitability of icy moons

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch comet 24P playing tag with Virgo's galaxies, then swing to a double-double in Eridanus

When to use this chart

1 Dec 00:00 AEDT (30 Nov, 13:00 UT)
15 Dec 23:00 AEDT (12:00 UT)
31 Dec 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

DECEMBER HIGHLIGHTS

As comet 24P/Schaumasse nears its January perihelion, it approaches maximum brightness (eighth magnitude) in late December in Coma Berenices, on the Virgo border. It rises in the early hours alongside the new Moon on the 20th. In December's final week, it crosses the Virgo Cluster, forming striking conjunctions with several of its brightest members, such as Markarian's Chain, and passing within 1.5° of M98 (25th), M99 (26th), M100 (27th), M88 (29th) and M91 (30th).

STARS AND CONSTELLATIONS

December's evening skies are quite barren, but two first-magnitude stars stand out. Fomalhaut (Alpha (α) Piscis Austrini), the 18th-brightest star, has the luminosity of 15 Suns, but its proximity (only 25 lightyears away) is the reason for its prominence. Achernar (Alpha (α) Eridani), the ninth-brightest star, lies 144 lightyears distant, but is six times more massive and over 2,400 times brighter than the Sun! Its rapid rotation – only 2.2 days – causes extreme flattening.

THE PLANETS

Saturn sets around midnight mid-month in the western evening sky, with Neptune close behind – about 4° apart and both visible in the same binocular field. Jupiter rises at twilight's end and transits in the early morning. The gas giants have favourable lunar conjunctions in December: Jupiter lies 5° southeast of the gibbous Moon on the 7th; Saturn lies 7° southwest of the first quarter Moon on the 27th. Uranus transits mid-evening, while Mercury is deep in the eastern dawn glow.

DEEP-SKY OBJECTS

This month, a trip to the constellation Eridanus. Nearly overhead in the late evening is a handy marker to this mostly faint constellation: a naked-eye double-double star. Dark skies are preferable to see these fourth-magnitude stars made up of two pairs, each 1° apart: Upsilon (υ^1 and υ^2) and, 5° away, υ^1 and Delta (δ) Eridani. They're a binocular treat, with υ^1 being blue-white, while the other three are yellow.

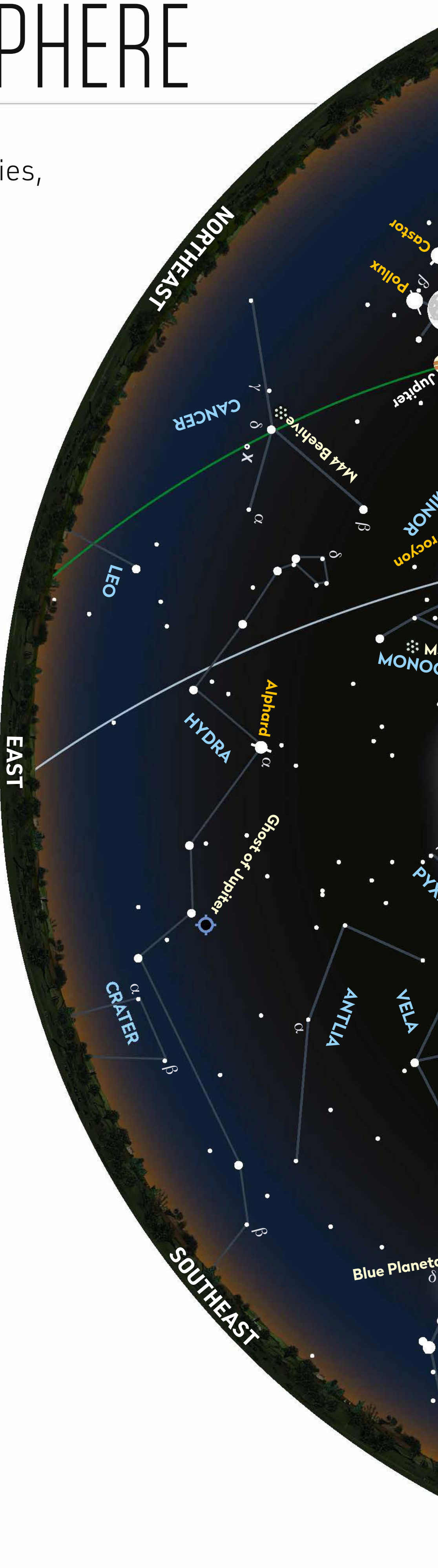
From υ^1 move 1.5° northwest to a true gem: galaxy NGC 1532 (RA 4h 12.1m, dec. –32° 53'). This 10th-magnitude edge-on spiral shows a 4 x 0.5-arcminute mottled halo that brightens to a prominent core. Adjoining NGC 1532 is a faint, 1-arcminute near-circular haze, its companion galaxy NGC 1531. Only its halo is visible, with little brightening towards the centre. Look for a distinctive seventh-magnitude star, just 0.2° to the northeast.

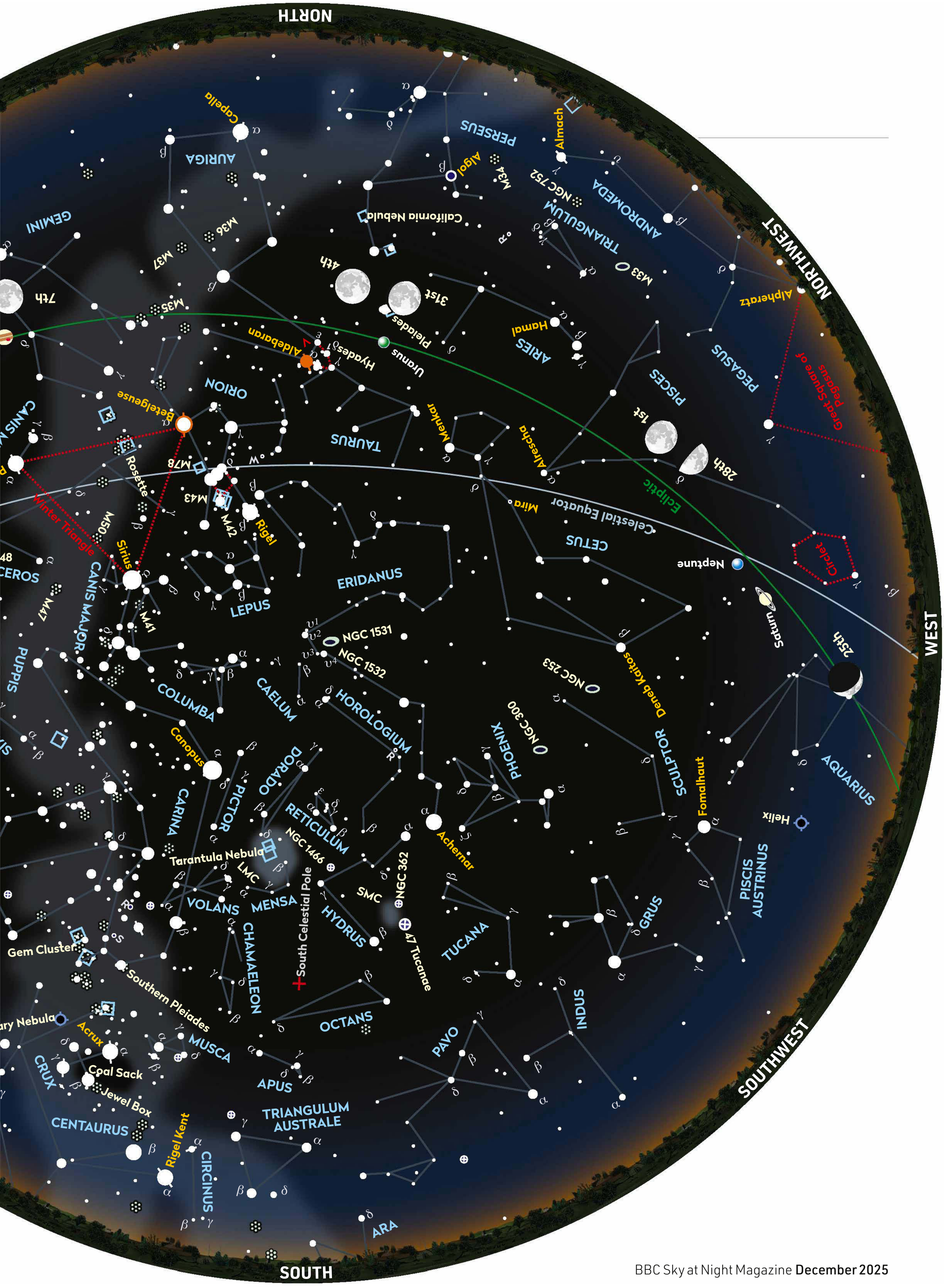
Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE




NORTH
WEST
NORTHWEST
SOUTHWEST
SOUTH
Capella
AURIGA
PERSEUS
Almach
Algol
M34
NGC 752
ANDROMEDA
TRIANGULUM
California Nebula
GEMINI
M36
M37
M35
7th
4th
31st
Pleiades
Hyades
Aldebaran
Uranus
M33
Alpheratz
Hamal
ARIES
PISCES
PEGASUS
Great Square of Pegasus
ORION
Betelgeuse
CANIS MINOR
TAURUS
Menkar
Alrescha
1st
28th
Ecliptic
Celestial Equator
M78
M43
M42
Rigel
Rosette
Winter Triangle
M50
Sirius
MONOCEROS
CANIS MAJOR
M47
M41
Mira
CETUS
Neptune
Circlet
ERIDANUS
LEPUS
NGC 1531
NGC 1532
Saturn
25th
PUPPIS
COLUMBA
CAELUM
HOROLOGIUM
NGC 253
Deneb Kaitos
NGC 300
PHOENIX
SCULPTOR
Fomalhaut
AQUARIUS
Helix
Canopus
CARINA
PICTOR
DORADO
RETICULUM
Achernar
Tarantula Nebula
LMC
NGC 1466
South Celestial Pole
SMC
NGC 362
47 Tucanae
VOLANS
MENSA
HYDRUS
TUCANA
GRUS
PISCIS AUSTRINUS
Gem Cluster
Southern Pleiades
CHAMAELEON
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